

1973

# Identification, measurement, and incorporation of environmental quality objectives in natural resource development

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Identification, measurement, and incorporation of  
environmental quality objectives in  
natural resource development

by

Herbert David Schellenberg

A Dissertation Submitted to the  
Graduate Faculty in Partial Fulfillment of  
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## CHAPTER I. INTRODUCTION

The development of natural resources to meet various demands of mankind and the impact of such development upon the quality of the environment is of public interest and concern. Environmental quality is emerging as a goal in the societal objective function, which includes economic development and improved income distribution. Development of natural resources to meet the economic development objective may well become competitive with the goal of environmental quality. Furtherance of one goal may lead to a lessening or degradation of the other. It is the general purpose of this study to seek the nature of trade-offs between these two societal objectives. Emphasis is placed upon those qualities of the environment which are inadequately priced and allocated in the marketplace.

## The Meaning of Environmental Quality

Despite higher per capita consumption of final goods and services, there is no assurance of improvement in the quality of life because of possible sacrifices of amenity and aesthetic services provided by the environment. The production and consumption of intermediate and final goods and services has affected the ability of the natural environment to provide desired aesthetic and amenity services.

Aesthetic services of the natural environment, as defined in this study, are those characteristics of the natural environment



appreciated by people because of their beauty and which as external stimuli excite admiration and delight in the human senses. Amenity services of the natural environment, on the other hand, refer less to beauty and more to those qualities of the environment which are simply pleasant and agreeable so as to make life more enjoyable. Air, for example, which is pleasant to breathe and free of smog, dust, and odors, and other quality reducing contaminants refers to amenity services. Aesthetic services, for example, are provided by beauty in nature such as the shape and color of a flower, or the fall foliage of trees. Throughout this study, for convenience, environmental amenity services, amenity services, and amenities are used to represent amenity and aesthetic services provided by the environment but not allocated in the market system.

Barkley and Seckler use a similar approach for nonmarketed services of the environment in terming non-market capital as the stock of amenities available at the beginning of a production period. A production period is begun "with a certain stock and quality of air and water, open space, quiet, wildlife, natural beauty, health, and related items" (7, p. 39). Likewise, Freeman, in discussing the distribution of environmental quality, notes that two burdens imposed by air pollution are health effects and disutility and amenity losses, including physical damages to structures. He states that people prefer to reside in higher quality air because adverse effects "to health, amenities, or nonhuman property" can be avoided. However, since there is a

scarcity of areas with highest quality of air, land values will tend to be higher in such areas and occupied by households with highest incomes (31, pp. 262-263).

Environmental quality, as used in this study, is a measure of amenity services flowing from natural resources in the environment. It is first useful to determine the physical meaning of environment before the term environmental quality is explored further. Daubenmire states that the term habitat can be used to denote a rather specific kind of environment or living space. More precisely, a habitat is "a constellation of interacting physical and biological factors which provide at least minimal conditions for one organism to live or a group to appear together" (25, p. 4). If man is the focus of attention, the term environment subsequently refers to the habitat in which he must live with his fellows, namely the earth. Environment, construed by reference to habitat thus refers to the one way flow from the surroundings to the organism. If the flow goes both ways in that the organism also affects the environment, and leading to an exchange of materials between the living and non-living parts, the unit is then called an ecosystem as long as it achieves functional stability over some time period (62, pp. 8-9; 25, pp. 7-8). A reduction in the ability of an ecosystem to provide the required type of habitat may therefore entail reduction of the quantity of life supported. Hence, an ecological concept of environmental quality refers to the ability of an ecosystem to remain functioning over

time.

Such a definition is construed in a quantity format. If the quantity of life as measured in terms of numbers of living units, pounds of biomass or some other physical measure, is increasing over time it can be said that environmental quality is improving. In the opposite case, environmental quality can be said to be declining if fewer numbers or pounds of biomass can be supported over time. However, for environmental quality to remain a meaningful term, it must be related to a particular type of living organism. For example, suppose that it so happens that over time human beings cease to exist because of some external reason related to their habitat. If another species flourishes instead, environmental quality has decreased to zero for the human race and improved for the species which can live and expand in the "new world".

Environmental quality, however, when considered in this manner is not fully meaningful because the quality of life is not incorporated into its meaning. Traditionally, in economics, it has been assumed that the quality of life for a particular human individual is maximized when his utility function is at the highest level possible subject to the stock of resources available. These resources yield utility to the individual by providing desired goods and services to ensure his existence and to meet other wants. However, since utility has never been fully measured, it is impossible to recognize when utility is at a maximum. On the

other hand, proxies for utility can be obtained by calculating price-quantity equivalents, which when expanded to total society becomes the familiar measure known as gross national product. Non-priced goods and services are not included in such a measure and therefore price-quantity relationships do not accurately represent the level of utility obtained by individuals.

Environmental amenities are among services provided by natural resources which are not fully priced by the market process and subsequently not allocated in the market system. Quality of environmental amenity services is analogous to the quality of other goods and services. In a market system higher prices exist for market goods and services of improved quality because of the increased level of satisfaction that such goods and services provide. On the other hand, even quantity measures of environmental amenity services cannot generally be obtained in monetary terms because non-payers cannot be excluded and preferences are not therefore revealed.

Hence, an economic meaning of environmental quality refers simply to the quantity and quality of amenity services provided by natural resources. Quantity aspects refer to specific measures of various amenity services provided, while quality aspects focus upon particular types of environmental services which offer various levels of amenities. Measures of quantity can be illustrated by referring to such units of measurement as acres, numbers, tons, of specific resource categories that provide amenity services.

Measures of quality are more difficult to obtain since they depend upon subjective preferences of each individual

### The Role of Natural Resources in Meeting Demands of Mankind

Amenity services are not the only services demanded by mankind. Other goods and services are demanded. This section discusses the role of natural resources as inputs to desired production and consumption processes.

#### The meaning of natural resources

A resource is an input to a production process. Natural resources are used in the production of environmental amenity services. Natural resources, as stated by Timmons, refer to those resources found in nature such as air, water, soil, minerals, sunlight, vegetation, wildlife, topography, and temperature (78, p. 3). Natural resources can also be defined as a function of the state of technology. Since technology is potentially infinite the supply of natural resources under this latter definition can also be considered infinite. A resource which has a zero price today as an input in a technological process may become valuable in the future because technical change has discovered a role for that resource in the production function of some desired commodity. Likewise, a resource which was in demand in the past may become unimportant in terms of quantity demanded as cheaper substitutes are discovered to serve the purposes formerly met by the resource.

Technology is important in reference to environmental quality since the flow of amenity services can be affected by employing specific resources. Technology can be used to develop alternative resource substitutes which will lessen the effect on environmental amenity services and can still be used as inputs to produce other goods and services.

Natural resources can be classified according to roles or services provided for man. These, as summarized by d'Arge (1, p. 12), can be categorized into four major types of services: (1) source of raw materials, (2) space for waste accumulation and storage, (3) assimilation-regenerative capability for chemically or biologically active wastes, and (4) determinant of health level and life style, and of aesthetic satisfactions. These services are highly interdependent. To obtain these services man must interfere with ecosystems to extract his needs, whether they be for direct requirements such as consumption goods and services as in the case of living space, or indirectly as in the case of raw materials. In return, man replaces these services with the discharge of wastes from production and consumption processes. Both the extraction of materials from natural systems and the return of waste products produce shocks which affect the equilibrium of the ecosystem.

Additional meaning can now be placed upon environmental quality. Environmental quality is being maintained if the ecosystem is stable in that it can withstand these shocks over time

and still provide desired environmental amenity services. However, if the extraction of materials is sufficiently large, or the return of waste products is greater than the assimilative capacity, the equilibrium of the system may be disturbed so that it is no longer capable of providing former levels of amenity services. This leads to a reduction in the quality of the environment. Some people may even believe that there is a threat to the human race, entailing a drastic change in patterns of production and consumption.

#### Demands for natural resources

Because of the possibility of substitution of resources to meet particular demands, it is meaningful to classify services provided by natural resources. Such a classification is a demand approach to natural resource analysis. On the other hand, the classification of services provided by natural resources, discussed above, is a supply oriented approach.

Six major demand categories for goods and services which require natural resources in their production can be identified, as follows:

- (1) Sustenance--This demand class includes such items as food, water and air of such quality to sustain human life at some basic level;
- (2) Fabricants--Items which are manufactured in a production process can be placed into this class. Most of

these items are used in conjunction with other demand classes;

- (3) Transportation--Transportation is required because of the spatial separation of production and consumption. A storage component is frequently involved;
- (4) Communication--Information is distributed by communication so that supply and demand are known to decision makers. It is also important for such objectives as education and social well-being, in addition to others;
- (5) Energy--Energy of many diverse forms is required in the form of derived demands resulting from the existence of other demand classes;
- (6) Recreation, aesthetics, amenities--This category includes those values demanded by people which contribute to the "general well-being" of human life.

An inherent element of each of these classes is quality. Environmental quality is affected by the nature of production processes in terms of inputs required and residuals generated. The production of energy, for example, can occur by various methods, each with its peculiar external effects upon the ability of the environment to supply amenity services.

Since all of these demands are interrelated there is need to evaluate alternative natural resources development possibilities in order to select quantities and qualities of goods and services which will best promote social welfare.



## Environmental Quality and Economic Development

This section discusses environmental quality as a goal of society. Trade-offs result when one social goal must be sacrificed to achieve an alternative goal or objective. Recognition and comparison of trade-offs is a possible means of improving social welfare in the absence of market price environmental amenities.

### Environmental quality as a recognized goal of society

That environmental quality is becoming recognized as a goal of United States society is evidenced by recent legislative achievements which directly affect natural resource development. At the Federal level, President Nixon signed into law on January 1, 1970, the National Environmental Policy Act (NEPA) which established a national policy on the environment, in addition to placing new responsibilities on Federal Agencies to take environmental factors into account in their decisionmaking.<sup>1</sup> The Act also created a Council on Environmental Quality in the Executive Office of the President to aid and advise in environmental matters.

NEPA, however, is not the only Federal legislation signifying the emergence of environmental quality as a social goal. Especially noteworthy was the establishment of the Environmental Protection Agency (EPA) in December, 1970. Consolidated into one agency were the major Federal programs dealing with air

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<sup>1</sup>The full text of NEPA is reprinted in 21, Appendix B, pp. 243-249.

pollution, water pollution, solid waste disposal, pesticides regulation, and environmental radiation (22, p. 4), with the responsibility to administer and implement Federal pollution control programs in these fields.

These two Federal legislative achievements are discussed more fully in Appendix E of this study, where focus is upon distinguishable effects of NEPA upon the Federal Government. Similar legislative achievements are evident at the state level. For example, Iowa passed in 1971 the Iowa Soil Conservation Districts Law. The general policy of this Act is to "provide for the restoration and conservation of the soil and soil resources of this state. . . .", in addition to the control and prevention of soil erosion and damages occurring from erosion, floods, and sediment deposition (42, p. 2158). The Act established power to set and enforce soil loss limits. For management purposes six soil conservancy districts were created in Iowa. The general policy was " . . . to preserve and protect the public interest in the soil and water resources of this state for future generations. . . ." (43, p. 2176). To date the program has been ineffective, especially because of inadequate funding to carry out proposed plans. Federal assistance for this program was withdrawn in 1973 to curb federal spending and thereby aid in controlling inflation.

Such curbs on spending illustrate choices that must be made by society in the development of natural resources to meet social

goals. Discussed next are the trade-offs that are often necessary between the two social goals of environmental quality and economic development.

Trade-offs between environmental  
quality and economic development

Krutilla et al. use the term "gifts of nature" in reference to the class of fixed and irreplaceable assets which arise from the "accidents of geomorphology, biological evolution, and ecological succession" (50, p. 71). These assets have no direct substitutes; once destroyed they cannot be easily replaced. The flow of amenity services from these assets, if desired, can be maintained over time by preserving the original state of the environment. Where preservation exists, as in the case of parks or scenic and unique areas, opportunity costs are created in terms of the forclosure of alternative uses of the resources.<sup>1</sup> Identifying trade-offs between the social objectives of environmental quality, measured by the amount of amenity services provided by the environment, and economic development, leading from natural resource development, illustrates the nature and magnitude of these opportunity costs.<sup>2</sup>

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<sup>1</sup>Opportunity costs are the benefits from alternative choices that have to be given up in order to obtain the benefits of the actual choice.

<sup>2</sup>The U.S. Water Resources Council, in its 1970 and 1971 reports by a special task force, has elevated the social goal of environmental quality to an equal level with other social goals of economic development and regional income distribution (89, 90). In addition the 1970 report included social well-being as a fourth major social goal (89).

Economic growth refers to increases in the per capita output of goods and services valued at market prices. Economic development is a process in which human and physical resources are utilized "to bring about a sustained per capita increase in the output of scarce goods and services," subject to the distribution of these goods and services not being made less uniform (32, p. 116). Natural resource development is a subset of economic development, and is used interchangeably with economic development in this study. Benefits from natural resource development are commonly measured in monetary terms and entered into the gross national product (GNP).

Market prices, however, frequently do not exist to measure amenity services, used in this study to represent environmental quality output. Nevertheless, environmental quality may be estimated by the quantity and quality of natural resources which provide amenity services. These resource costs can be measured in physical units such as acres or grams/liter. The use of natural resources to produce marketed outputs creates costs which are the cost benefits obtained from amenity services otherwise available. Hence a trade-off curve can be developed by using a physical measure for environmental quality on one axis and a monetary measure for economic development on the other. Such a curve summarizes production possibilities for the two social objectives. The slope of the curve, once obtained, provides an estimate of the magnitude of opportunity costs of one objective in terms of the other at any desired level of one of the social objectives. The

problem, however, is that the nature of trade-offs, the shape of the curve, and the subsequent opportunity costs is frequently not known for comparing the objectives of economic development and environmental quality.

If GNP could be corrected by subtracting "non-material disamenities that have been accruing as costs to our economy", as argued by Samuelson (72, p. 102), a measure of net economic welfare (NEW) could be obtained which would render a trade-off curve unnecessary. The social goal would be to maximize NEW. The difficulty, however, is one of measuring the non-material amenities in order to correct the total market value of goods and services. A first step in measuring non-material amenities is identifying the trade-off curve discussed in the previous paragraph.

#### The Problem of Identifying and Measuring Amenity Values

Previous sections of this chapter have sought to determine the meaning of environmental quality, the role played by natural resources in meeting mankind's demands, and trade-offs between environmental quality and economic development. This section presents the problem of direct concern in this study, the problem of identifying and measuring the loss of amenity values resulting from natural resource development by construction of multiple-purpose reservoirs in Iowa. Amenity values of concern are those flowing from land and other natural resources inundated by such reservoirs.

Once the magnitude of amenity losses have been estimated, comparison can be made with project contribution to economic development, aiding in determination of project feasibility.

#### Multiple-purpose reservoirs in Iowa

In Iowa, three multi-purpose reservoirs have been constructed since 1958 (83, 85). A fourth, the Saylorville project, is under construction and expected to be completed by 1974 (85). A fifth, the proposed multiple-purpose Ames Reservoir, is in the active planning stage (81) and is of direct concern in this study because of the anticipated loss of amenity values flowing from the resources to be inundated if the project is constructed as planned.

Each of these projects completed, under construction, and proposed, have features in common. All have been planned by the United States Army Corps of Engineers. Benefit-cost ratios greater than unity have been calculated for each signifying their feasibility. In addition, each reservoir constructed or under construction permanently floods from 4,900 acres to 16,700 acres of land, as indicated in Table 1.1.

The Ames Reservoir on the Skunk River in Central Iowa, as proposed by the Corps of Engineers, would permanently flood about 2,100 acres of land to provide storage for water quality control and reservoir recreation. Up to another 3,000 acres would be intermittently flooded as water is stored for flood control. The project was initially recommended for construction in 1964 with a first cost at that time of 10,130,000 dollars, and a benefit-cost

Table 1.1. Summary of multiple-purpose reservoirs in Iowa<sup>a</sup>

Project name	Year completed and status	Construction cost (millions of dollars)	Acres flooded in conservation pool
Coralville reservoir	1958 (completed)	15.5 (1958 prices)	4,900
Rathburn reservoir	1969 (completed)	26.5 (1970 prices)	11,000
Red Rock reservoir	1969 (completed)	85.4 (1970 prices)	8,950
Saylorville reservoir	1974 (under construction)	54.9 (1970 prices)	16,700
Ames reservoir	in planning stage	18.2 <sup>b</sup> (1968 prices)	2,100

<sup>a</sup>Sources: (85, pp. 1206-1211; and pp. 1362-1363; 83, p. 1238; 79, p. 1157; 80, p. 830; 81).

<sup>b</sup>Includes 1.1 million dollars already spent in relocating and raising the grade of Interstate 35 which was originally planned to transect the reservoir site.

Acre-feet storage in conservation pool	Acre-feet storage in flood con- trol pool	Benefit- cost ratio	Project purposes
53,750	475,000	1.7	Flood control, conservation
189,000	339,000	1.6	Flood control, naviga- tion, water quality, recreation
90,000	1,740,000	2.5	Flood control, recrea- tion, fish and wildlife
74,000	602,000	1.8	Flood control, recrea- tion, water quality, fish and wildlife
26,100	89,500	1.6	Flood control, water quality control, fish and wildlife, recreation



ratio of 1.7 to 1 (84). Later plans have a first cost of 18,200,000 dollars in 1968 and a revised benefit cost-ratio of 1.6 to 1 (81, 82).<sup>1</sup> The Ames Reservoir is therefore smaller than the other projects summarized in Table 1.1, but still of considerable scope and capital expense.

Project construction of the Ames Reservoir is delayed because of the requirement of an environmental impact statement to accompany the project proposal for funding, as required in the 1969 National Environmental Policy Act (21, pp. 243-249). To determine the environmental impact of the project a measure of cause-and-effect seems insufficient since this does not measure demand for environmental amenities if there is simply a listing of natural resources that will be flooded. Hence, to compare the planned benefits of the project from its stated purposes of flood control, water quality improvement, and reservoir recreation with the value of alternative resource uses at the site, it is necessary to determine the demand for the environmental amenities that will be precluded if the project is built. These values were not considered in the benefit-cost analysis of project feasibility. Values include those stemming from enjoyment of the present site for its vegetation and wildlife resources, as well as values derived from the stream itself in the reach to be flooded.

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<sup>1</sup>The 1968 revision added two subimpoundments to the project to enhance recreation potential. These would require about another 185 acres of land to be flooded.

Multiple-purpose reservoirs and environmental quality

In reference to the specific problem of determining the effect on environmental quality by the construction of multiple-purpose reservoirs in Iowa, it is useful to classify various categories of demands which may be affected by reservoir inundation. Such demands may exist at various levels, including zero. Possible demands are adapted from a 1971 report by the U.S. Water Resources Council (90). Five demand classes for various categories related to environmental amenities are subsequently listed as follows:

- 1) demands for areas of natural beauty such as open, green spaces, including natural wooded areas, and wildlife,
- 2) demands for the free-flowing stream or streams that will be replaced by the artificial lake or lakes,
- 3) demands for undeveloped areas of prairie, woods, and other ecosystems in equilibrium for their historical and intrinsic values,
- 4) demands for scientific values obtained by studying possibly unique ecosystems,
- 5) demands for the preservation of freedom of choice to future resource users.

Proximity to communities is a factor for consideration of resources that serve the above demands (with the possible exception of (4)) because implications exist for income distribution.

If areas that meet the above demands are "abundant" but only at a considerable travel cost, those of low monetary incomes cannot enjoy their attributes. Time of travel is also a non-monetary cost in order to enjoy the amenity services, even for the affluent. Therefore, a matter for consideration in addition to preservation is that of ready access and convenience--to provide net amenity values after subtraction of access and travel costs.

Assuming the economic feasibility of the project from conventional benefit-cost analysis, the decision must be made whether or not the net benefits from the project to achieve the social goal of economic development are sufficiently large to offset the loss in amenity values when natural resources are affected by construction. Determining the absolute value of environmental amenities appears to be a basic purpose of preparing environmental impact statements. If the absolute size cannot be obtained in units of dollars to facilitate comparison with net benefits from project construction, at least a knowledge of trade-offs should facilitate achievement of the social goals of economic development and environmental quality. Revealed will be the sacrifice of one objective in order to obtain an increase in the level of the other.

Although the amount of amenity values at the Ames Reservoir site is unknown the level is expected to be of magnitude which should not be ignored. The project would inundate a scenic valley, destroy or seriously modify about 1300 acres of mostly original Iowa upland and lowland forest, destroy most of the wildlife in

the 2,100 acres of permanent pool area, in addition to destroying or damaging portions of local parks, remnants of uncultivated prairie, and potholes (16, 65). The problem is estimating relative and absolute levels of benefits flowing from environmental amenities provided by the natural resources in the area to be flooded by the Ames Reservoir.

### Objectives of Study

Growing out of the problems associated with investment decisions in natural resources to meet direct and indirect demands of mankind, the objectives of this study are to:

- (1) define the nature of environmental quality in terms of its meaning and economic characteristics,
- (2) review alternative methods for determining the magnitude of environmental quality objectives and benefits,
- (3) develop a methodological framework to incorporate environmental quality objectives into natural resource development evaluation procedures,
- (4) apply and test this framework in the Ames Reservoir, and
- (5) suggest further research needs in the analysis and achievement of environmental quality objectives.

In order to resolve problems, it is necessary to understand the inherent nature of the fundamental elements of the problem-- in this case, environmental quality. The purpose of the first objective, therefore, is to assess characteristics of environmental

quality which have led to its exclusion from the market allocation process. This is done by focusing upon the meaning of environmental quality and upon the anticipated environmental effects that the proposed Ames Reservoir will have by flooding certain natural resources in the region. Reasons are then explored for the failure of environment quality objectives to be included in the evaluation procedures of natural resource development.

The purpose of the second objective is to appraise existing methods pertaining to environmental quality in order to isolate models which can be used to estimate environmental quality benefits and costs. The third objective seeks to incorporate useful features of these existing models in order to develop a model which can be used in the case of evaluating feasibility of multiple-purpose reservoirs as found in Iowa.

The fourth objective applies and tests this model to the specific situation as presented by the proposed Ames Reservoir. This indicates the potential of the model in being made operational and hence provides a test of its usefulness.

The fifth and final objective is to analyze difficulties remaining in the method and procedure and to suggest additional research needs to improve the analysis and achievement of social environmental quality objectives.

## Methods and Procedure of Study

### Theoretical development

This portion of the study deals mainly with the first three objectives. Theoretical considerations in the analysis of environmental quality are explored. Focus is upon the failure of the price market system to efficiently allocate environmental amenity services. Market failure is judged to result from the public good characteristics of environmental quality. Criteria for economic performance are analyzed in an effort to determine a criterion which will best incorporate the objective of environmental quality in a multiple-social objective framework. The criterion selected is one which develops a production-possibility curve between environmental quality and economic development and then selects a "best" point of maximum desired social output by (1) monetary evaluation of environmental quality and economic development benefits to determine which combination will maximize net benefits, and (2) comparison of trade-offs between environmental quality and economic development if environmental quality benefits cannot be fully determined because of the non-priced nature of output. This latter procedure is not fully determinate, however, but guidelines are developed to indicate directions of increased social output. Included in the assessment of trade-off possibilities is a critical discussion of two major existing methods of preparing environmental impact statements since such statement preparation represents the isolation of trade-offs between environmental quality and economic development.

### Analytical procedures

The method developed in the theoretical analysis is applied and tested using data from the proposed Ames Reservoir. After consideration of the evaluation methodology as employed by the U.S. Army Corps of Engineers, net benefits from their project benefit-cost analysis can be used as a measure of benefits flowing from economic development.

Physical impacts on natural resources that will be affected by the project are employed to form a basis for estimation of the overall environmental impact of the project. A public survey of residents in a nine county region surrounding the proposed project is used to rank seven natural resource categories as to relative importance. A measure of the absolute value of the environmental amenity services which would be maintained by preservation is obtained by estimating visitation and monetary benefits (using a willingness-to-pay model) that result by placing the resources that would be inundated into a green-belt park system. Regression techniques are employed to determine household variables that affect responses and to predict possible changes in demand as population characteristics vary over time. Finally, the analytic procedure is completed by describing trade-offs and comparing values between environmental quality and economic development as evidenced in the specific Ames Reservoir project. The method described above illustrates how environmental quality objectives can be incorporated into natural resource development evaluation procedures.

### Organization of Report

Chapter I presents the problem to be studied, the objectives of the study, and introduces theoretical and analytical procedures used. Environmental quality is defined and discussed as a goal of modern society. The meaning of natural resources is described, as well as demands for their services. Trade-offs between environmental quality and economic development are presented. The specific problem to be studied is shown with reference to impacts of multiple-purpose projects in Iowa upon amenity values. The proposed Ames Reservoir is chosen for empirical analysis because of the anticipated impact upon amenity values in the region to be flooded.

In Chapter II the failure of the market system to allocate environmental amenities is analyzed. The chapter includes a comparison of criteria for measuring economic performance which include environmental quality as a social objective. Chapter III summarizes and evaluates alternative existing models for imputing market values by indirect and non-market techniques.

The model used in this study is developed in Chapter IV. Chapter V described the physical impact of the Ames Reservoir upon natural resources, the design of a public survey, and questionnaire development. Chapter VI presents empirical results. The last chapter, Chapter VI, summarizes the study, discusses limitations, and provides recommendations for future research.



## CHAPTER II. THEORETICAL CONSIDERATIONS

### IN ENVIRONMENTAL QUALITY ANALYSIS

There remain many unanswered questions in formulating and achieving the goal of environmental quality. This chapter deals with the question of why the market or resource allocation process in meeting mankind's demands has failed to meet the demands for environmental quality. Such failure is evidenced in the preparation of legislation, for example the 1969 National Environmental Protection Act, which by institutional reform has forced the explicit incorporation of environmental quality objectives into resource allocation procedures.

After isolation in this chapter of characteristics which result in environmental quality being excluded in the priced market process, five criteria for economic performance are presented and discussed. A criterion is required in order to gauge the success or failure of alternative allocation possibilities. Two criteria are selected that provide theoretical directives for the incorporation of environmental quality objectives into the process of resource allocation. These two criteria are employed in latter chapters of this study to illustrate how environmental amenity services can be embodied into economic decision-making.

#### Environmental Quality and the Price System

The failure of the price system to allocate natural resources in the production of amenities is the focus of this section.

Amenities are not commonly sold and exchanged in the marketplace. The advantages of a price system in the allocation of natural resources are now discussed, after which externalities and public goods are presented as reasons in the failure of the price system to consider amenity services in the exchange process.

#### The price system and Pareto optimality

Traditionally, resource allocation and income distribution in market-oriented economies has been guided by the price system. However, because of the frequent unacceptable results when the price system is relied upon entirely, there is, as described by Harl (36), substitution of a legal system to provide necessary guidelines for resource allocation and income distribution. This is evidenced by the legislation discussed in Chapter I and Appendix E. Not only does the existing stock of legislation show that environmental quality parameters are important in the public view, but also that the price system has failed to adjust and provide automatically those environmental services that people now value.

The price system nevertheless has significant advantages. In particular it provides decentralized impartial operation that, without monitoring, is continually adjusting to changing tastes, incomes and resource supplies. A perfect price system is one in which all goods and services, including amenities, are priced relative to their scarcity and their contribution to the utility of consumers.

An assumption frequently made by economists is that it is

desired for a price system to result in a Pareto optimal allocation of consumption. An allocation is defined to be Pareto optimal if production and distribution cannot be reorganized to increase the utility of one or more individuals without decreasing the utility of others. Furthermore, it is a central theorem in economics that the equilibrium conditions of a system of competitive consumption and production markets correspond exactly to the requirements of Pareto optimality (48, p. 49; 37, p. 262). However, the conclusion that perfect competition leads to Pareto optimal allocation is contingent upon the assumption that there are no external effects in consumption and production. External effects arise when the utility level of a consumer depends upon the consumption of others and when the total cost of an entrepreneur depends upon the output levels of others (37, p. 267).<sup>1</sup> For competitive equilibrium and Pareto optimality to correspond exactly is therefore dependent on the accurate transmission through the price system of all the effects of one economic unit's choices on the well-being of other economic units. When the price system fails to accommodate effects upon and demands for environmental services, Pareto optimality is then not likely to be achieved.

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<sup>1</sup>In a general equilibrium analysis, it is a necessary condition that externalities be defined as a problem of interdependencies. However, because the general economic problem is also one of interdependencies between and among producers and consumers as "there is not enough to go around", the sufficient condition for external effects to exist is, as stated by Mishan (58, p. 184): ". . . when relevant effects on production or welfare go wholly or partially unpriced".

The existence of external effects or externalities are frequently cited as reasons for the failure of the price system to allocate resources in a Pareto optimal manner. Ownership externalities and public good externalities are now discussed because of their relevance to environmental quality. The purpose of this discussion is to diagnose and seek reasons for the apparent failure of the price system to allocate environmental amenities. If such externalities are found to result in the failure of the price system, remedial measures may be identified which can be later embodied into the resource allocation process.

#### Ownership externalities

In a well-functioning competitive market economy each productive resource is employed up to the level where the cost of an additional unit of input is just equal to the value of additional product. Therefore, under perfect competition, profit maximization is achieved by producing that volume of output where marginal cost equals price. Resources will be allocated, and goods and services will be produced and consumed subject to prices as determined by supply and demand.

Environmental amenities, however, as defined and discussed in Chapter I are prevented from falling into the price market system because they appear to be characterized by the problem of ownership externalities. Ownership externalities, as classified by Bator (5), are one major form of external effects that involve private goods and services. Private goods and services are those

characterized by competing consumption. On the other hand, public goods and services, discussed more fully later in this chapter, are goods and services characterized by non-competing consumption. Public goods and services, generally termed public goods, represent a second form of external effect, according to the classification of Bator.

Ownership externalities are associated with the failure of the resource user to bear the full cost or damage of his action. A farmer, for example, in the area of the proposed Ames Reservoir may wish to clear some native Iowa woodland to create additional crop acreage. So doing, however, may affect negatively the consumption of another person who enjoys hunting rabbits or picking flowers (depending on preferences) in the woods and is now deprived of these services.

External costs have been created by the action of the landowner. These are the costs associated with the loss of amenity services provided by the woods. The landowner has not compared his gain with the utility loss of others. Such a loss is often termed a social cost. The problem resulted since no price was charged by the owner for the scarce services provided by the woods.

Therefore, in the presence of external costs that are not monetarily priced, the market fails to consider them in the allocation of resources. Too much of the good or service will be produced in view of the damage it causes, and too few resources

will be devoted to the maintenance and protection of the desired amenity service.<sup>1</sup>

It is useful, as described by Hulett (41), to define ownership externalities to include cases of Marshallian joint supply where all the products are private goods, but where at least one of the products is characterized by infeasibility of exclusion. Such a definition permits a clear distinction to be drawn between cases in which the failure of competitive market outcomes to be Pareto optimal is related exclusively to private goods, and cases where failure is due to the existence of public goods. In general, ownership externalities, as stated by Meyer (57, p. 1), result from the inability to define or enforce property rights to a private good clearly enough so that the good can be allocated efficiently by the market.

In the above example where the flower picked or the rabbit hunted can be considered as private goods, it may be possible for the landowner to exclude the user of the woods and thus enforce his property rights by constructing a fence or some other technological innovation. If such policing to enforce property rights is prohibitively expensive or impossible, the ownership externality is still unresolved. If it were possible, prices could be charged by the landowner for the amenity use of his woods and the market restored.

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<sup>1</sup>For a thorough analysis of the problem of externalities with reference to water quality, use and treatment, see Kneese and Bower (46, Chap. 5).

Since private goods are being considered, compensation is a valid tool to resolve the externality. Free bargaining is possible between the two parties. As shown by Coase (19), Pareto optimality can be achieved either by forcing the harm-creating party to compensate the harmed for his losses, or the harmed bribing or compensating the owner for his losses in retaining the woods in its original state. Consequently, in the two-party case the "problem of social cost" can be resolved. Hence, the choice of whether the land-owner must legally compensate the wood user is one based on equity rather than efficiency.

When there is a large number of harmed parties, individual members of the group will recognize that it is entirely rational for them to understate their true marginal evaluations for the reduced harm. In this way they will be able to secure the benefits of the service (enjoyment of the woods) without contributing to the cost of enticing the land-owner to curtail his wood-clearing activity if bribing is the method being used to resolve the ownership externality. On the other hand, if the land-owner is being forced to compensate the harmed groups there will be the problem of people overstating their true preferences in order to receive more than they would pay themselves. Such individual and independent action will be nonoptimal for the group as a whole. This problem of liars and free riders then prevents optimal allocation of the good in question.

When the number of parties that consume the services of the

woods increase, ownership externalities become the problem of public good externalities.<sup>1</sup> This results since the services of the woods are characterized by non-competing consumption up to points of congestion. Non-competing consumption is a key characteristic of public goods.

#### Public good externalities

A "Samuelson-type" public good (often termed collective good) is a good or service characterized by non-competing consumption for two or more consumers. Following Samuelson, all consumers enjoy the good in the sense that each individual's consumption of such a good leads to no subtraction from any other individual's consumption of that good (71, p. 387). That is, more of the good

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<sup>1</sup>Buchanan and Stubblebine (14) have defined an externality to be present in a consumer's utility function when,

$$U_A = U_a (X_1, X_2, \dots, X_m, Y_1).$$

This states that the utility of an individual, A, is dependent upon the activities,  $(X_1, X_2, \dots, X_m)$ , that are exclusively under his control, and also upon  $Y_1$ , which is under the control of a second individual. A Pareto-relevant externality is defined as one which can be modified in such a way that the externally affected party, A, can be made better off without the acting party, B, being made worse off. However, in cases where there are more than one externally affected parties, their definition of externality is exactly the same as Samuelson's definition of public goods. That is, there is non-competing consumption since no individual's consumption of the good will lead to a subtraction of some other's consumption of the same good. Hence, as shown mathematically by Hulett (41, pp. 60-66), the Buchanan and Stubblebine treatment of "externalities" is actually a treatment of public goods.



or service for one person will automatically result in more for the other. Hence, as stated by Bowen (10), the "demand" curve for a public good is obtained by the vertical summation of individual "demand" curves.

Figure 2-1 illustrates how aggregate "demand" for a public good such as the amenity services of woods are obtained in a two consumer world. The curves  $D_1D_1$  and  $D_2D_2$  represent individual "demand" curves for the public good in question. The curve  $DD$  represents the aggregate "demand" curve. Vertical summation is necessary because the good may be consumed simultaneously by all consumers. Public goods are in contrast to private goods. In

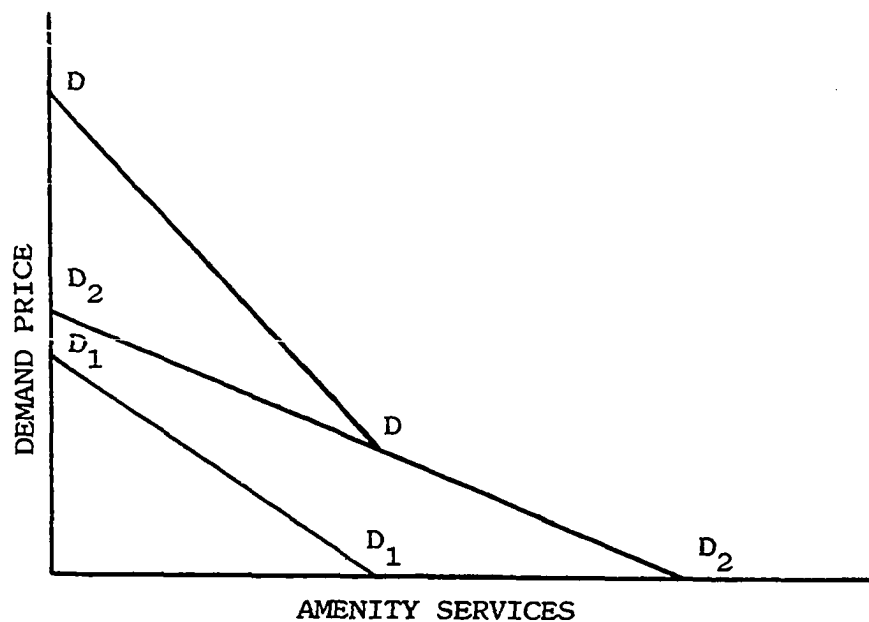


Figure 2-1. Aggregate demand for amenity services

private goods, consumption is competing since consumption of the good by one person precludes consumption of that same good by anyone else. Aggregate demand for private goods is therefore obtained by horizontal summation of individual demand curves. A hamburger is a typical example of a private good, while national defense is frequently cited as an example of a public good.

Italics around demand in demand curves are used in the above discussion because these are not true demand curves for public goods analogous to demand curves for private goods. As argued by Hulett (41, p. 36), "an individual's demand curve (curve of marginal evaluations) for a public good does not represent the prices that he necessarily must pay to consume various quantities of the good, since the possibility exists, even if the price is not paid, that the public good will be supplied by others."

Joint supply, frequently called joint products (37, p. 89), occurs whenever a production process yields more than one output. The outputs may be two private consumption goods, such as beef and hides, or they may be mixed goods such as the joint provision of a private and public good, often called merit goods (41).<sup>1</sup>

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<sup>1</sup>Vaccination against a contagious disease is an example of a private and public good in joint supply. The vaccine is a private good since no one else can consume that same particular unit. But, by not contracting the disease, the person who has been immunized is also supplying a public good to unprotected people with whom he comes in contact (57, p. 2).

Joint supply may also involve two or more public goods. An example is the creation of a lake which provides both swimming and fishing. Up to the point of congestion, or depletion of fish stocks, both goods are characterized by non-competing consumption.

Non-competing consumption can also be applied conceptually to "negative" public goods, or "public bads". Hence, if the quality of water is degraded in a stream by some activity, then a public "bad" has been created. In this context, however, it is somewhat easier to think in terms that less of the original public good, the prior state of water quality, is available after its original quality was deteriorated by the introduction of wastes and residues from other production and consumption processes. Also, it is possible to consider that a new public good has been created, but of lower quality.

Amenities have characteristics of public goods. Consumption of the pleasures of an attractive forest or stream valley is non-competing, up to points of congestion or levels of destruction. It could be active consumption as in the case of participating in on-site outdoor recreation or passive consumption such as deriving pleasure from the preservation and passing on the native forest for future generations to enjoy as the present generation does now. Preservation of the forest for one person or group will automatically preserve it for others. Similarly, up to congestion levels, consumption of forest-based recreation by one

individual will not preclude consumption by another.

Problems in allocation thus arise in the provision of public goods. The demand for privately produced goods can be determined in the market place. In regards to public goods, where consumption is non-competing, no objective way exists for determining demand since it cannot be sold in the marketplace. If a firm tried to sell the good, it would pay for people to understate their preferences and hence give inaccurate answers. This is the "free rider" problem, or "why should I pay if no one else does?" The problem justifies government intervention in the provision of public goods such as environmental quality. People might more likely vote to be taxed if everyone else must also pay. Allocation is still not likely to be optimal, however, since some people may be forced to pay more than the real value they place on the good, while others might obtain the good at a bargain, realizing some "consumer surplus," since the tax bill is less than the real price they would be willing to pay. There is thus the problem of arbitrariness and allocation of costs, but, at least, the good will now enter the decision-making process of society, and its provision be explicitly considered.

#### Criteria for Economic Performance

This study has still not dealt in detail with the problem of deciding which combinations of production and consumption of private and public goods and services are to be preferred. Criteria are needed which will judge alternative technological

possibilities for allocating goods and services. One of the first assumptions economists must make in devising and employing economic theory used in the allocation of limited (scarce) resources is to assume that the task of an economy is to maximize some measure of societal welfare. That is, the task of an economy is to produce the combination of goods and services that will maximize societal welfare subject to technology and resource availability. With acceptance of this statement of purpose, which can be used as a goal, economists have arrived at criteria for economic performance which are used to judge the "worth" of policies and decisions that affect production and consumption by society.

Dorfman and Dorfman have listed five criteria for measuring economic performance (28, pp. xx-xxxiii). The first two, representing one pair, are termed utility criteria. These relate to the success of the economy in promoting welfare or satisfaction. The next two, representing a second pair, are referred to as the productivity criteria. The productivity criteria refer to the success of the economy in producing goods or other physical results. These two pair of criteria relate to the efficiency of the economic system in producing goods and services. A fifth criterion deals with equity, and is therefore called the equity criterion. These five criteria are now discussed to determine the usefulness of each to the problem of allocating output of environmental amenities and other services such as flood control, outdoor recreation, and water quality that would be produced by the proposed Ames Reservoir.

### Utility criteria

Of the two pairs of efficiency criteria, the first and most fundamental pair relates to the success of the economy in promoting welfare or satisfaction. It is assumed in the utility criteria that community welfare is based upon the welfare of individuals. Individual welfare is generally called utility. Individual utility levels are based upon the consumption of goods and services, including amenities flowing from the environment.

If the utility from all conceivable elements entering the consumption function of individuals can be measured, a utility-possibility frontier could then be specified by determining the locus of all Pareto optimal points of the economy. This locus constitutes the first member of the utility criteria pair for economic performance. This locus is useful for measuring economic performance because it indicates the possibility of improvements in social welfare if the allocation of production, consumption and a subsequent utility is such that present distribution of welfare is not Pareto optimal. Such would be the case, for example, at point A on Figure 2-2 where the solid line represents the utility-possibility frontier in a two individual society. From the allocation represented by point A it is possible to change the operation of the economy to make one member better off while holding the other at a constant level of utility.

This criterion, however, does not distinguish between alternative Pareto optimal points on the frontier. There are numerous

Pareto optimal points, one for each given utility level of a societal member. Each point on the frontier therefore corresponds to one particular distribution of welfare to societal members. The question remains of choosing that point which is "best" for the society. Distinguishing between alternative points on the frontier is the purpose of the social welfare function, whose addition to the model constitutes the second member of the utility criteria pair.

A social welfare function can be represented, theoretically, by a family of social indifference curves, analogous to an individual's utility map. A number of social indifference curves, corresponding to a particular social welfare function, are illustrated for the two-individual society in Figure 2.2. They are represented by the dotted lines. At point E, corresponding to the highest social indifference curve, societal welfare will be maximized in this simplistic society.

To relate the usefulness of the utility criteria to the problem of environmental quality it is necessary to recount conceptual difficulties in the approach. As shown by Arrow it is impossible to achieve a democratic social welfare function that will unambiguously rank all possible societal alternatives. He stated in his Possibility Theorem that, if the possibility of interpersonal comparisons of utility is excluded, "then the only methods of passing from individual tastes to social preferences which will be satisfactory and which will be defined for a wide range of

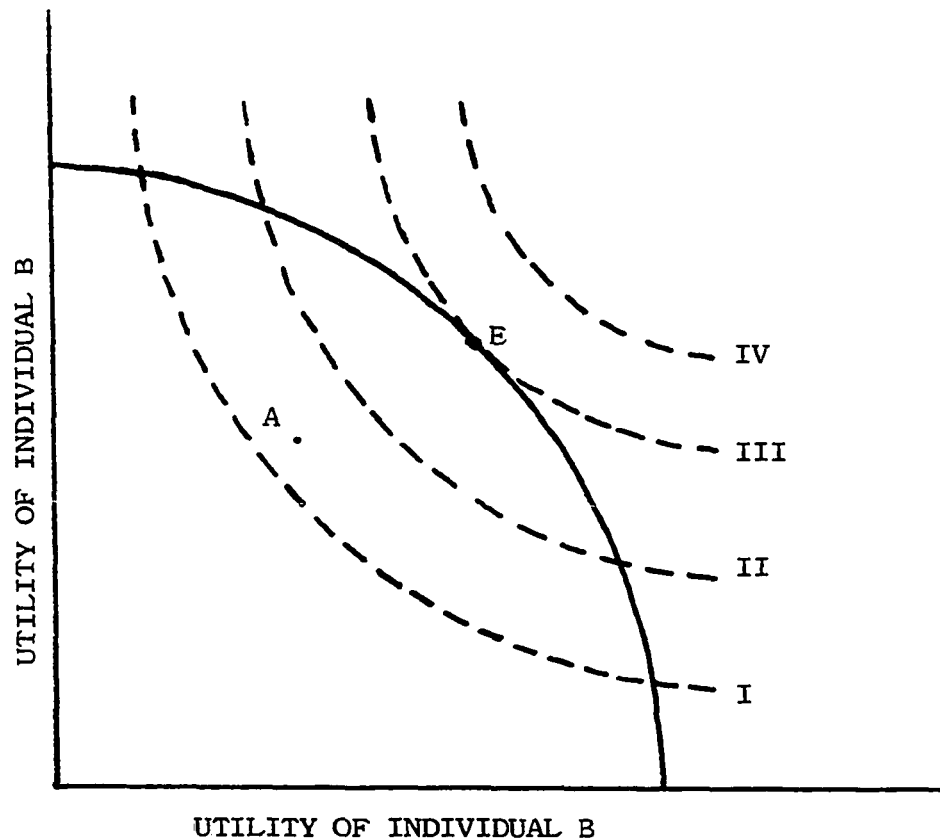


Figure 2-2. The utility-possibility frontier with social indifference curves

sets of individual orderings are either imposed or dictatorial" (2, p. 164). Mishan has stated that even if Arrow had proved that, in principle, a completely satisfactory transition from any set of individual orderings to an ordering for society was always possible, the route to the continually changing position of maximum social welfare "would have been too arduous for the most accomplished econometrician to plot, to say nothing of prompting humanity to



undertake the journey" (58, p. 62). Hence, there exist both theoretical and practical problems of determining a social welfare function.

In regards to utility, its measurement and usefulness is open to question. Despite the simple requirement that only a preference ordering is required to provide an explanation of market demand, or even the nature of the utility possibility frontier and hence Pareto optimality, this requirement is excessively demanding in practicality. In addition, as pointed out by Roberts and Holdren (68, pp. 16-22), there are problems such as adjusting to continual change, wants are not static and uniformly perceived, information requirements are immense, and the possibility of learning is ignored. They argue that preferences are not given, as assumed in the received utility theory of consumer behaviour, but rather all preferences are learned.

The utility criteria therefore appear to be unsuited to the task of evaluating the level of environmental quality at the site of the proposed Ames Reservoir. Both the utility from amenities and the project outputs cannot be obtained by any practical method. A social welfare function is unavailable. Therefore, attention is now turned to the second pair of efficiency criteria, the production criteria.

#### Production criteria

The second pair of criteria for measuring economic performance refer to the physic productivity of the economy. These two criteria

concentrate on goods and services that are technically measurable, thus rendering analysis that is not dependent upon the measurement of utility. Instead of maximizing utility, the objective is to maximize the quantity of goods and services that provide utility subject to resource and technological restraints.

Analogous to the utility-possibility frontier in the utility criteria, the production-possibility frontier in the production criteria is specified by producing the greatest amount of goods and services that are technically possible, given the output of all other goods and services. An economy is said to be productively efficient if it is operating somewhere on the production-possibility frontier. Productive efficiency is a necessary condition for Pareto optimality. Allocation of production so that the economy is operating somewhere on the production-possibility frontier represents the first criterion of the production criteria pair, termed the broad productivity criterion.

Just as there are many Pareto optimal points on the utility frontier there are many Pareto efficient points on the production frontier. The decision process of choosing the best point constitutes the second member of the production criteria pair. Since prices in the market reflect the relative desirability of goods and services, and if consumers adjust purchases so as to equate marginal rates of satisfaction for each additional unit of income, then the highest level of monetary value of all possible combinations of goods and services that provide utility can be considered

the best point on the frontier. This highest level of market value is the maximum gross national product (GNP).

Production criteria appear therefore to be relevant in resolving problems of environmental quality. Instead of actually measuring utility flowing from amenities it is possible to measure the physical resources that provide such utility. First, however, it is necessary to identify resources or resource categories that provide amenity services. In the case of the Ames Reservoir project this would involve identification of natural resources in the region that provide utility such as the forest, wildlife, and the scenic valley. The next step is to measure the acres and types of forest, the numbers and species of wildlife, miles of stream, and so on. These could represent the outputs of environmental quality.

On the other hand, outputs of the project would be measured in terms of additional bushels of grain resulting from flood control and additional days of water oriented outdoor recreation if these were the only two planned outputs. Suppose that a production-possibility frontier could be developed which would indicate the greatest physical amount of amenity services that is technically possible holding the output of the project goods and services at constant levels. Identification of such a frontier is useful since comparison with the actual allocation of output would indicate if increased production is possible by reallocation of production.

In the GNP criterion it is assumed that all goods and services can be priced to reflect their marginal valuations. In

reality, however, not all goods and services are priced because of the existence of externalities. In addition to ownership externalities, the presence of public goods creates problems in determining market prices for commodities characterized by non-competing consumption such as environmental quality. Because of the possibility of unrevealed preferences true social value may not be expressed by the market value. Therefore, maximum GNP is not likely to choose the best point on the production frontier.

Benefit-cost analysis represents an application of the maximum GNP productivity criterion. Benefit-cost is used to determine which combination of priced outputs and inputs will yield the maximum contribution to GNP. Since benefits are represented by the market value of output, and costs are represented by the market value of inputs to produce the outputs, that combination of production which will maximize net value of output will also maximize the net contribution to GNP. The absolute level of GNP does not need to be calculated by itself as the maximum net addition to GNP ensures that GNP will be maximized.

It can now be seen why benefit-cost analysis as used in the Ames Reservoir project and other multiple-purpose reservoirs projects in Iowa is inadequate as a measure of judging feasibility of the resource re-allocation involved. Only priced inputs and outputs were incorporated into the analysis. These feasibility studies have not considered other costs which are not priced such as the sacrifice in amenity services caused by inundation.

Four criteria for economic performance have now been presented and discussed. The remaining one considered for relevance in this study is that of equity, termed the equity criterion, discussed next.

#### Equity criterion

So far only efficiency in promoting utility and production has been mentioned as a desired feature of economic performance. Any change on a production or utility-possibility frontier will result in a change in income distribution. If a social welfare function were available the problem of equity would be solved since a social welfare function incorporates equity in its makeup. In the absence of a social welfare function conflicts of interest as evidenced by each Pareto optimal point cannot be accommodated by the model. If the maximum GNP criterion is accepted, the current distribution of welfare will be enshrined since current prices are used, reflecting the current distribution of income. Use of benefit-cost analysis subsequently accepts the current income distribution, which might be "inequitable".

Generally it appears that income distribution is resolved only in an ad hoc manner since economists do not know what is equitable. However, economists can point out distributional aspects of alternative policies. In environmental quality, for example, policies designed to enhance or maintain amenity services will shift the distribution of equity to those who consume these services, with resulting less income for those who must sacrifice other goods and

services. Thus, while it cannot be said which policy is equitable, at least it is possible to employ the four efficiency criteria to indicate directions of income distribution for alternative points on or within the frontiers.

#### Directives for this Study

With this review of characteristics of environmental quality and criteria for economic performance, certain directives have emerged which are used in achieving the study objectives. Because none of the five criteria for gauging economic performance were satisfactory by themselves it was felt necessary to employ more than one. Consequently, the two production criteria were chosen for application in this study as economic performance measures because they did not deal with the vague notion of utility and effects on equity could be noted in the production criteria.

The GNP criterion was relevant because there appear to be methods by which amenity services can be priced. Non-market and indirect techniques exist for evaluating non-priced values or benefits, especially in the economic analysis of outdoor recreation. Potential exists for adapting certain of these methods to environmental quality analysis. Additional methods for estimating values exist by calculating economic benefits resulting from improved states of the environment, especially water and air quality.

A second criterion, the broad productivity criterion, was also considered relevant because it was impossible to obtain monetary equivalents for amenity services that could be relied upon fully.

The broad productivity criterion requires knowledge of the production-possibility frontier. If environmental quality objectives, measured by stocks of natural resources that provide amenity services, are entered on one axis and other outputs, such as those obtained from multiple-purpose reservoir construction, are entered on the other, comparisons can be made of alternative points on the production-possibility curve. Trade-offs can be isolated, including effects upon income distribution. It appears that the requirement of environmental impact statements to accompany Federal Government project proposals are an application of this method, when monetary prices are not estimated for amenity values.

The next two chapters deal with requirements for the application of these criteria to the problem of natural resource allocation. Chapter III discusses non-market and indirect techniques for imputing non-priced values. Conceptual difficulties in these techniques are noted where relevant. The basic purpose of imputing price values is to apply the maximum GNP productivity criterion. Focus in Chapter III is upon the literature involved with outdoor recreation. Many similarities exist between the provision of facilities for outdoor recreation and the protection and preservation of natural resources which provide amenity services. Amenities can be "consumed" actively, as in the case of participating in outdoor recreation, or passively, in the case of deriving pleasure and satisfaction from the simple knowledge that "it still exists", without physically going to see it.

Chapter IV deals more thoroughly with the broad productivity criterion, in a multiple social objective framework. Of particular importance is the measurement of outputs for the social objectives of environmental quality and economic development. Methods of measuring both are reviewed.



### CHAPTER III. IMPUTING MARKET VALUES BY INDIRECT AND NON-MARKET TECHNIQUES

Five basic methods for imputing market values by indirect and non-market techniques are discussed and compared in this chapter. These methods represent current techniques for imputing money equivalents of non-existent or imperfect market values in outdoor recreation and environmental quality analysis. The purpose of this comparison is to choose a technique which can be adapted, or best aid in devising a "new" technique, to determine monetary price values of environmental amenities as exemplified in the case of the proposed Ames Reservoir. The five methods are (a) interview techniques, (b) travel-cost techniques, (c) pricing by government decree, (d) estimation of preservation benefit levels required to exceed development benefits, and (e) benefit estimation by environmental improvement.

Each method attempts to convert available physical and economic information about the goods and services under consideration into a common denominator of monetary terms. These monetary terms can then be used to aid in determining that mix of activities which attempt to meet the maximum GNP productivity criterion. The theoretical validity of each method is discussed and compared. Reference is made to the possible incorporation of each method into project benefit-cost analysis in order to include all costs and benefits of resource development projects.

Two willingness-to-pay methods, interview and travel-cost

techniques as used in the economics of outdoor recreation, are presented in the first section. Included is a discussion and review of consumer surplus, describing its relevancy to empirical studies. Measurement of consumer surplus is extensively used in these two methods. The second section of this chapter discusses the method of valuating recreation benefits by "government decree". This method is relevant because it was used by the Corps of Engineers in their benefit-cost analysis of the Ames Reservoir. It also offers potential in valuating environmental amenity services.

The third section of this chapter presents the model employed by Krutilla and fellow researchers at Resources for the Future, Inc., in which the level of preservation benefits at Hell's Canyon required to be equal to or greater than development benefits were calculated. The fourth section reviews methods for estimating benefits by calculation of direct monetary effects resulting in environmental improvement, as used in studies for determining optimal levels of air and water quality.

A fifth section of this chapter involves a discussion of discount rates to calculate present values of future returns. Appropriate discount rates are important in environmental quality analysis and the GNP criterion because of present and future time preferences in the consumption of environmental amenities. The chapter concludes with choice of the model used in this study to incorporate environmental quality as a desired social output in the maximum GNP criterion.

### Willingness-to-Pay Methods

Willingness-to-pay methods, as used in the economics of outdoor recreation, attempt to first estimate demand for recreation at a particular site and then impute recreational monetary value by estimating the area under the demand curve, known as consumer surplus. Two basic alternative approaches are discussed in this section. One is to use personal interview techniques by asking recreationists to state the amounts they would be willing to pay if recreation were purchased in a market system. The second approach estimates demand by using travel-costs of recreationists as proxies for price. Interview techniques are discussed first.

#### Interview techniques

Demand for the good or service is estimated by personal interviews of a sample of users. Primarily used in outdoor recreation, users are asked to state the maximum price they would pay in order to avoid being deprived of the use of a particular area. The purpose is to discover the price, or willingness to pay, if the good or service were actually purchased in the open market. The total measure sought is the area under the demand curve termed consumer surplus. Magnitude of the integral, the area under the curve, is then used as the total measure of recreational benefit and entered into the benefit-cost analysis. This method is described in detail by Knetsch and Davis where they compare results using this technique, and the travel-cost technique (discussed next) in a study of outdoor recreation in Maine (47).

There are two major theoretical sources of bias in applying interview techniques to a good or service with public good characteristics such as outdoor recreation and environmental quality. One is that respondents may understate their preferences in order to avoid paying charges based upon their reply. In this way they can minimize their own costs if the good will be provided. On the other hand there is incentive to overstate their preferences to strengthen the case to preserve the area of concern in its current use, possibly knowing that taxes levied will not be as large as the sum stated.

Bohm (9, pp. 94-105) argues that these biases can be minimized if more than one payment alternative is specified. If the possible user faces the possibilities, with unknown probabilities, of paying the amount corresponding to his stated maximum willingness to pay or of paying nothing at all (federal funds used to finance a local project entirely) then his incentive to distort statements will be reduced. Although the "free rider" possibility may still be present, the possible user must live with the fear that the good or service will go absolutely unprovided if he refuses to state some positive value as his maximum willingness to pay.

A 1972 study employing the technique of interview methods in valuating goods and services provided by outdoor recreation is a study by Brown and Hammack (12). They questioned waterfowl hunters as to the amount that costs would need to increase before the hunter would forego his hunting. From this Brown and Hammack

obtained an estimate of the total net value of hunting for a representative hunter. After consideration of production costs, these values could be used to select a time-sequence for hunting and provision of wetlands that will maximize the net on-site values. Empirical problems, however, especially in regards to wetland productivity, did not allow Brown and Hammack to provide a confident conclusion for maximizing hunting values.

A main theoretical rationale for using interview techniques is that it attempts to directly measure the demand for the resource under question. With knowledge of the demand curve, the area under the curve can be calculated to obtain a measure of consumer surplus. If the actual user charge or fee is approaching zero, so that price-quantity calculations add little meaningful information (a free good), then, according to proponents of this method, only by calculating a measure of consumer surplus will an idea of value be obtained. Consumer surplus appears only with downward sloping curves, where price is not a constant.

Much controversy exists in economic literature over the measurement and meaning of consumer surplus. This controversy is examined to more extent in the later part of this section because of its role in willingness-to-pay models and benefit-cost analysis.

Additional limitations of direct interview techniques are now presented. In addition to the liar's problem as mentioned above, there is the considerable problem that people must

be approached directly to elicit information. Considerable research expense is therefore required. An intricate questionnaire and skilled interviewers are required to avoid biases. Although Brown and Hammack used a mail questionnaire to cut costs, response was about 50 percent. In this way survey costs were reduced but the researcher must assume that the 50 percent who replied constituted an unbiased sample of the total user population for the study to be useful. In addition, questions posed are hypothetical. Thus, even if answers are unbiased, there is not guarantee that people will do as they say. There is also reason to believe that coefficients obtained are unstable, especially over time. Replies depend upon the knowledge and experience set of individuals. A small increment in knowledge may affect values provided by individuals, especially since questions and answers are hypothetical.

Nevertheless, there appears to be considerable merit to the interview technique in evaluating recreation benefits. In regards to calculating values for amenities, the technique appears worthy of consideration. Although the recreation applications imply that there is direct physical use, this is not necessary. If people obtain satisfaction from simply preserving the woods, whatsoever the reason, then one can say the woods are being "used" and questions of value are relevant.

#### Travel-cost techniques

Travel-cost techniques are a major alternative to the direct-interview methods. Instead of asking users how much they would

be willing to pay or spend, information is obtained from users about travel costs incurred to reach the site in question. The travel-cost technique has been extensively employed in the literature of outdoor recreation. First proposed by Clawson in 1959 (18), applications were made by Brown, Singh, and Castle for fishing in Oregon (13), by Merewitz in on-site water-oriented recreation (56), by Goldstein for water-fowl evaluation (33), by Battelle Columbus Laboratories in a system of state parks (17) and others.

The technique uses travel cost data as a proxy for price in imputing a demand curve for recreation facilities. Two basic steps are involved. The first is concerned with estimating a visitation-prediction model, usually using concentric circles or political organizations as travel origins. This results in a cost-visitation relationship. The second major step involved derivation of a "demand schedule". Assuming that the populations in the origin areas are entirely homogeneous,<sup>1</sup> it is posited that if those nearby had to face the same "entrance fees" as those more distant, those nearby would attend at the same rate per capita as those more

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<sup>1</sup>Pearse (64) objected to the necessity of assumptions about the characteristics and homogeneity of the base populations. Instead, he grouped recreationists into similar income levels. In each income class, the visitor with the highest travel cost was chosen. By subtracting travel costs for the others in that income class, a measure of consumer surplus is obtained. Now, however, the assumption is made that visitors from similar income classes have identical indifference curves for outdoor recreation, in addition to assumptions that visitors are geographically located in homogeneous regions.

distant. A demand schedule is then derived by hypothetically increasing entrance fees, by raising travel costs, for all origin regions until total visitation for all practical purposes approaches zero. Area under this curve is then calculated to obtain a total measure of consumer surplus, or value, attributed to the site under consideration. Frequently, total surplus is divided by the total number of visitors to obtain an average value of consumer surplus per visitor. The same can be done with the interview techniques.

There are practical and conceptual problems in the travel-cost approach, some of which are now stated. Basic is whether or not the schedule derived is a true demand curve. A true demand curve is a monetary price-quality relationship. In the travel-cost technique, additional variables to price are included in the dollar axis. Particularly important is travel time, which may be either pleasant or onerous depending upon circumstances. Hence, the surplus calculated may be in gross error. Other assumptions include homogeneous populations who will all react similar to changes in costs, equal quality of recreation experiences, that automobile travel costs can be equated to entrance fees, and that the sole purpose of the trip is to visit the site under question.<sup>1</sup>

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<sup>1</sup>A complex recent study concerned with the problem of valuation of "extra-market" benefits with particular reference to water-based recreation is that of Sinden (75). He employed methods of indifference mapping by public survey to obtain demand curves for alternative types of recreation in Oregon. Area under the demand curves was calculated to obtain consumers' surplus for various activities. Travel costs were employed as the measure of price.



With reference to the problem of amenity values, this technique as described above, unlike interview techniques, appears unsuited to the problem at hand. First, it is characterized by conceptual and practical difficulties. Second, and more important, it implies actual money costs and physical use, thus ignoring satisfactions obtained by those who value the resources "simply because they are there".

However, travel cost and interview techniques can be combined to measure amenity benefits as shown in the following discussion. A study of recreation in Wales by Norton (60) estimated benefits by using travel costs but avoided completely the issue of consumer surplus. Norton contended that the value attributable to any particular recreational site can be obtained simply by summing the total travel costs incurred by the visitors to reach the site. This sum is directly comparable to the total revenue for conventionally-priced market goods because consumers must allocate their budget between recreation expenses and other goods and services. Location is important, especially for the redistribution of welfare. By locating recreation areas near low income groups, or vice versa, real income to such groups can be increased.

Total willingness to pay to visit a site, or financially aiding in its establishment to preserve amenities, can be determined by interview techniques. Willingness to pay would include travel costs incurred by visitors to reach the site plus additional visit related expenses, in addition to sums of money that people

would directly be willing to spend to ensure site establishment even though they do not actually visit it. Since these sums represent budget allocations by the consumer they provide a direct measure of benefits equivalent to the total revenue obtained from market priced goods and services.

This innovation appears to be useful in the estimation of amenity benefits and is referred to again in later parts of this study.

#### Consumer surplus and benefit evaluation

Interview and travel-cost techniques discussed above, except the application by Norton (60), estimate benefits by calculating consumer surplus. Although the techniques can be commended because they attempt to obtain a demand curve, they can also be seriously questioned as to usefulness because of the use of consumer surplus.

There appear to be two main considerations involving the concept of consumer surplus. One involves the legitimacy of its use. The second involves the question of its measurement. These are now discussed in turn, as they are important in evaluating public investment alternatives.

Economics is based upon utility theory which is mostly unquantifiable. Most easily quantified is price-quantity relationships, leading to the maximum GNP criterion. Yet, "value in use" is always greater than "value in exchange" except for the trivial

case of horizontal demand curves. Since government intervention is for the purpose of altering price-quantity relationships, the relevant value to consider is value in use rather than the non-existent value in exchange when price equals zero as frequently appears to be the case in environmental quality. Hence, the economist, as described by Davidson (26), is led to consider the entire area under the demand curve, which is the value in use (from Adam Smith) or consumer surplus (from Marshall).

Hicks (38, 39), dissatisfied by Marshall's treatment, provided economists with several measures of consumer surplus. For planning purposes, Krutilla et al. (50, pp. 95-108) focused on Hicks price-compensating and price-equivalent measures of consumer surplus. When a good is being withdrawn, the price-equivalent measure is appropriate, assuming the status quo is relevant. This is the amount of money income in dollars that an individual who is presently consuming a good at a given set of prices must be paid to give up his right to continue consuming the good, permitting him to stay on his highest attainable indifference curve (50, p. 97).<sup>1</sup> On the other hand, a price-compensating measure of consumer surplus is required to be measured if new products are being contemplated. This is equal to the charge (or loss in income) that could be placed on the individual that would leave him at the same level

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<sup>1</sup>For a detailed exposition of consumer surplus, see Hicks (38, 39), Patinkin (63), and Mishan (58, 59). The subject is extremely complex and only treated cursorily in this dissertation.

of utility without consuming the good, assuming prices remain unchanged.

Mishan, 1971 (59, p. 338), concluded, however, that all measures of consumer surplus can be approximated in practical circumstances by use of the area under the demand curve. This would provide a measure of the relevant benefit or loss. For goods that have a zero income effect all measures will coincide. In most plausible cases, however, income effects involved are small because the majority of goods and services, especially in the public sphere, represent a minor part of the consumer's total consumption. Hence, according to Mishan, income effects can be ignored and the area under the demand curve used as the appropriate measure of consumer surplus.

In theory, then, where government intervention appears to be justified by the presence of public goods and externalities, to adjust price-quantity relationships, the market valuation of benefits is inadequate because it may equal zero or near zero. The alternative is "value in use", which can be approximated by the area under the demand curve. According to Mishan, it is difficult to see how losses and gains on any scale can be computed otherwise. However, because approximations are being made, a slight gain in surplus would be unconvincing evidence of the desirability of investment (59, p. 81).

Further support of this position is given by Harberger (35) who argued that the following three postulates be accepted

as providing a conventional framework for applied welfare economics. These are recognized as value in use, or consumer's and producer's surplus; the area under the demand and supply curves. As stated by Harberger (35, p. 785), the postulates are:

- (a) the competitive demand price for a given unit measures the value of that unit to the demander;
- (b) the competitive supply price for a given unit measures the value of that unit to the supplier;
- (c) when evaluating the net benefits or costs of a given action (project program, or policy), the costs and benefits accruing to each member of the relevant group (e.g., a nation) should normally be added without regard to the individual(s) to whom they accrue.

Note, however, that these postulates refer to all products equally. Thus, in comparing alternatives, especially public versus private development, which is required when price-quantity relationships are felt to be inadequate, the practice of estimating surplus appears to become unusable. For, if consumer's surplus is used on the benefit side, it must also be used on the cost side, as recognized by the postulates. But the costs involved include the value of private alternatives that must be foregone, argued also by Bromley et al. (11, p. A-3). One would need to assess the impact upon every good and service in the economy.

Even if surplus were fully legitimate, what about its measurement? Since area is involved, the functional relationship of a demand curve must be known between the vertical axis and the intersection with the supply or marginal cost curve. This is not an easy task to determine. At any period in time, only one point on the demand curve can be observed. The remainder is hypothetical,

although it can be estimated. To allow estimation, it must be given that all "other things are equal". Hence, as conceded by Hicks, consumer surplus "is limited by the same 'ceteris paribus' as the demand curve is limited" (38, p. 109). Consumer surplus is thus a partial equilibrium concept. This seems to be the weakest feature of consumer surplus making it next to impossible to measure.

Consumer surplus appears therefore to be extremely "fragile". It is unstable since it depends upon every other price and quantity in the economy. A slight change in any one price will affect it. Consumer surplus does not operate at the margin to equate marginal costs with marginal benefits, since most public investment is of a lumpy nature. Additionally, a demand curve may be estimated with considerable confidence only in a narrow range. Meaning is often lost when a demand curve approaches the vertical axis. It is then possible to have infinite consumer surplus with infinite price, or else face subjective cut-off levels of price.

Infinite surplus, for example, was shown by Brown and Hammack (12, pp. 180-181). When hunters were questioned as to the smallest amount they would accept to give up their right to hunt waterfowl for a season, a measure of price-equivalent consumer surplus, the percentage of hunters who replied that they would not sell their right at any price was 12.4 percent and the percentage who named a very high figure such as one million dollars was 1.4 percent. However, these were hypothetical answers to hypothetical

questions, and in practice, people may react differently. Since hunters are sure that they will never really sell their right, it appears for them to overstate their benefits, to ensure continued government provision of waterfowl to hunt, as well as possibly succumbing to a get-rich-quick personal syndrome. On the other hand, when questioned as to the increase in cost that would be required before they would choose to defer from hunting, responses seemed to be less emotional, and the average value of 247 dollars per hunter was obtained. Hence, two different methods of measuring surplus, and approximating a demand curve yielded considerably different results.

Summarizing, it was felt for purposes of this study that measurement and use of consumer surplus should be avoided because of the difficulties, both theoretical and empirical, discussed above. Estimation of demand curves, nevertheless, is useful in order to achieve knowledge of price-quantity relationships which can be employed to obtain other value estimates such as total revenue, used extensively in benefit-cost analysis. Demand curves can be measured by alternative methods, depending upon properties of goods and services in question. Where exclusion of non-payers is possible, alternative levels of prices could be assessed and the subsequent quantity consumed measured. Where exclusion is impossible, as is the case of consumption of environmental amenities, an appropriate recourse appears to be the use of direct interview techniques. Interview techniques would

be used to obtain willingness to pay for travel costs incurred plus willingness to spend to aid in maintaining the flow of amenity services over time.

#### Pricing by Government Decree

A third method in recreational analysis, in addition to interview and travel-cost techniques, is the use of institutionally created prices. These are employed by government agencies, such as the U.S. Army Corps of Engineers, in calculating recreation benefits at a proposed project. The quantity of visitors expected is multiplied by a common monetary value, adjusted to reflect the type and quality of recreation provided, to obtain a price-quantity sum.

This method is worthy of discussion in this chapter because it was actually employed by the Corps of Engineers in their benefit-cost study of the Ames Reservoir (81). The method can also be used for estimating values of "green-belt" park systems in which the stream and natural surrounding vegetation are the center of attraction rather than a lake. Hence, "pricing by government decree"<sup>1</sup> is of interest in this study because of the possibility of maintaining or enhancing the flow of environmental quality services at the Ames Reservoir site by developing the site into a "green-belt" park system. Potential visitors would be expected

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<sup>1</sup>I am indebted to Bromley et al. (11, p. 13) for the title to this classification.



to visit the park system to enjoy the contribution of environmental amenities to the recreation experience.

A modern example of government pricing is that recommended by the Water Resources Council in their 1970 and 1971 reports (89, pp. III-B-2-17; 90, p. 24157). The 1971 report states that a "general" recreation day, involving primarily those activities attractive to the majority of outdoor recreationists, is to be attributed a value in the range 0.75 to 2.25 dollars. This constitutes such activities as swimming, picnicing, boating, and warm water fishing. On the other hand, specialized recreation days are to be given values ranging from 3 to 9 dollars. These values are given to uses such as fishing and hunting where alternatives are more limited and costs are higher. It is interesting to note that in the 1970 report, it is recommended that values of 2.50 dollars to 7.00 dollars be used for specialized recreation. This illustrates the considerable subjectivity involved in this method.

A review of these documents of the Water Resources Council plus Supplement #1 to Senate Document 97 (88) suggests that this method has a market derived base. According to Bromley et al. (11, p. 15), "The pricing of recreation in Supplement #1 to Senate Document 97 is, in effect, a governmentally-created price although it is cast in such a way as to suggest it has a market-derived base (88). We do not place this practice in a market-valued monetary category described above because its analytic base is weak". They state further that to place it in a market-valued

base would require increased attention to the effect of future developments and to the basic evaluation of the market value of a recreation day.

In addition to these problems, there is a further difficulty in this method of benefit evaluation which has not been pointed out in recreation literature and which should be noted. This is the common practice to attribute all visitors a common value of benefits. Such a practice ignores that visitors may have unequal marginal valuations on their activities, owing from different levels of income, and varying tastes and pleasures. Considerable distortion can be caused by such practice, as shown in the following numerical example.

Suppose, for simplicity, that use of a travel-cost technique estimated the demand curve for recreation at a particular proposed reservoir in the form of:

$$P = 10 - .01Q$$

where P = price (equivalent to entrance fees)

Q = visitation.

If this curve is equal to the marginal utility curve of users, as required by Seckler (74), total consumer surplus can be calculated by calculating the shaded area under the curve as shown in Figure 3-1. Since, in practice, there are zero entrance fees, actual visitation will be 1,000 visitors. At a fee of \$10 visitation will be zero. Total consumer surplus is then

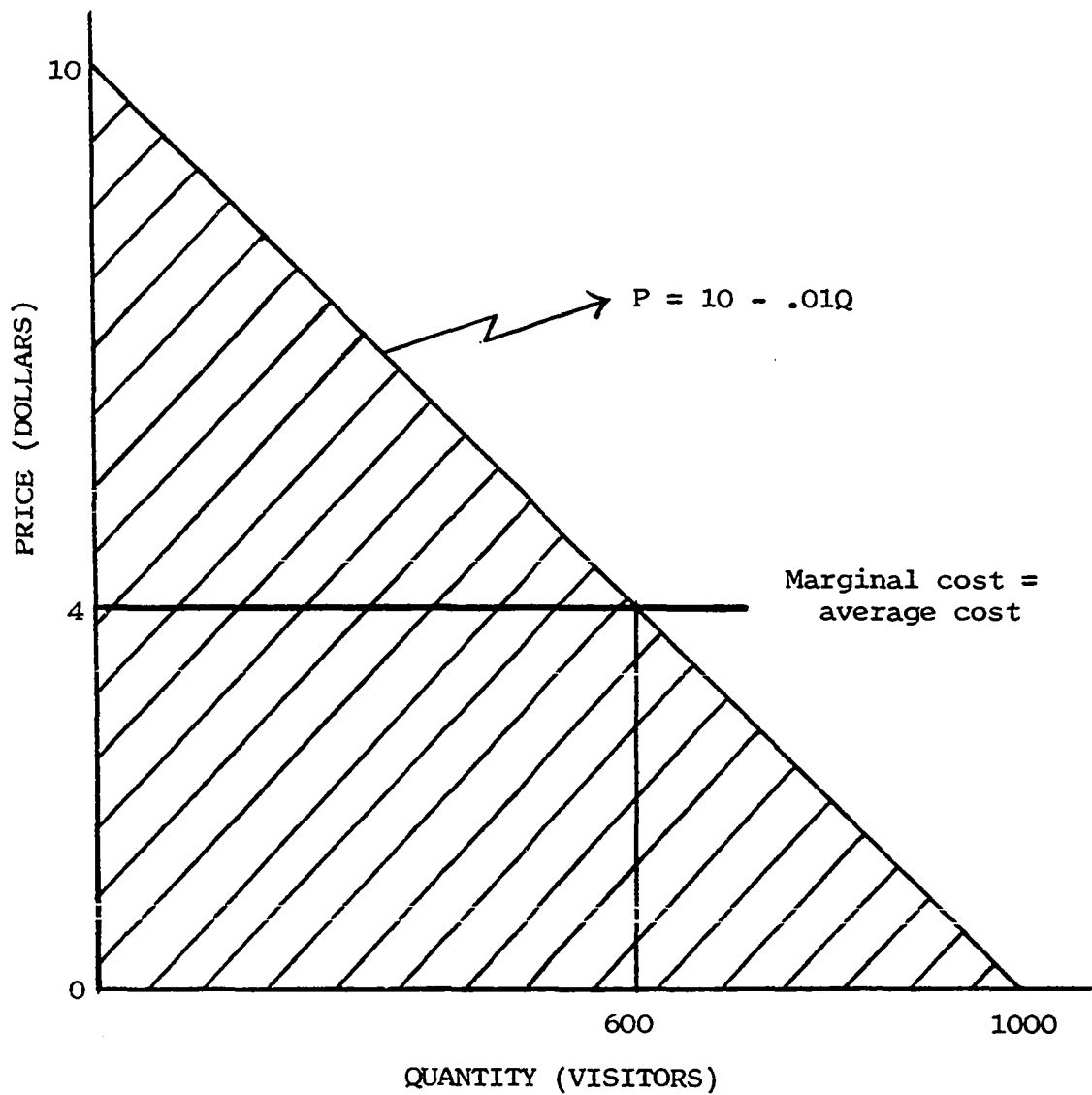


Figure 3-1. Hypothetical demand and cost curves for recreation at a proposed facility

equal to the area under the curve from 0 to 1000, which is \$5,000. Dividing by 1,000 visitors, an average value or benefit of \$5 per visitor is obtained. This benefit appears to be fully analogous to the government values quoted above.

Now suppose that the marginal cost per visitor for providing facilities is equal to \$4, and unchanging so that marginal cost is always equal to average cost. Then equating marginal cost to marginal utility, to achieve the most efficient scale of development, i.e.,  $4 = 10 - .01Q$ , a level of development of  $Q = 600$  is obtained. This is the "true" optimal scale of development. If development is greater, marginal costs are greater than the marginal benefits since the marginal cost curve is above the marginal utility schedule. At 600, net surplus, or the total consumer surplus minus production costs, is at a maximum.

Now, for comparison purposes, suppose that an agency is estimating the optimal scale of development using benefit-cost analysis. It knows that attendance will be 1,000 at a zero-entrance fee. It also draws up a table similar to Table 3-1, of total and marginal benefits, and total and marginal costs, using values of 5 and 4 dollars per visitor as marginal benefits and costs respectively.

At each increment of 100 visitors, additional benefits are still greater than the additional costs. Therefore, it pays to increase the size of development. Indeed, at 1,000 visitors, net benefits are largest, equal to \$1,000. This compares to net benefits of only \$600 at the "true" optimum level of 600 visitors, calculated in the previous paragraph. Further, with no budget constraint, there is incentive to recommend a development greater than 1,000, where all actual net additions to visitation cease,

Table 3.1. Hypothetical table of benefits and costs for a proposed recreational development

Total visitors	Total benefits	Additional or marginal benefits	Total cost	Additional or marginal costs	Net profit or benefit	<u>Benefit</u> cost
400	2000		1600		400	1.25
500	2500	500	2000	400	500	1.25
600	3000	500	2400	400	600	1.25
700	3500	500	2800	400	700	1.25
800	4000	500	3200	400	800	1.25
900	4500	500	3600	400	900	1.25
1000	5000	500	4000	400	1000	1.25
1100	5500	500	4400	400	1100	1.25

because this will still add to the net benefits since the ratio of benefits to costs is constant. As shown by this example, there appears to be validity to the statement that benefit-cost analysis uses average rather than marginal analysis, as argued by O'Connell (61, p. 32).

In summary, for optimal development, in this example a fee of \$4 should be charged to users. Those who lived nearby and previously had zero travel costs (equivalent to zero entrance fees) would now attend at the same rate as those that previously had a travel cost of 4 dollars. Those who previously had a travel cost of 4 dollars would now attend at the same rate as those who previously had 8 dollars and so on. Hence, where marginal costs are not insignificant, considerable resource misallocation can occur by developing recreation facilities to accommodate every possible user who will attend at a zero gate entrance fee.

Quality and efficiency must be considered along with quantity. Used in the above manner, recreation can be used to justify uneconomical multiple-purpose projects, those that would not "pass the test" without recreation. This has important implications for environmental quality, since projects damaging to the environment and economically unsound may be built without ascertaining demand curves for recreation, and without equating at the margin to obtain the optimal level of development. Likewise, for the national parks, if the marginal cost for providing facilities for additional visitors, such as roads, is non-zero and there exists actual or

potential environmental damage from overuse, there appears to be economic justification to limit park attendance, either by charging fees, or rationing if some income distribution motive exists.

With respect to amenities, pricing by government decree, although tempting, is unsatisfactory. Basic is the failure to determine demand, a problem which is not adequately dealt with in the method. This implies that specific research is needed to assess demand for recreation or amenities for every potential type of development.

#### Estimation of Preservation Benefit Levels Required to Exceed Development Benefits

This method is the fourth general method of imputing market values by indirect and non-market techniques to be considered in this chapter. Chief users of this method are personnel at Resources for the Future, especially Krutilla, who have applied it extensively to studies of the Hells Canyon where two incompatible uses exist for the same site (60). Some of the values provided by a natural area like the Hells Canyon in an undeveloped state can be calculated by outdoor recreation techniques. Other values, however, are yet immeasurable by economic techniques, such as the value of preserving rare scientific research materials. Because of these problems, they used an indirect approach for benefit evaluation of value. As stated by Krutilla et al. (50, p. 83), ". . . we ask what this value would need to be in order to equal or exceed the present value of the developmental alternative. And to get a better handle

on the problem, we ask additionally what the base year's annual benefit would need to be to have a present value equal to or greater than the developmental alternative". That is, they calculate the minimum value of preservation, aesthetic and recreation benefits, growing with increased tastes and populations, necessary to be greater than or equal to the present value of alternative possibilities for development.

If technology provides diminishing marginal utility from goods and services over time because of increased supplies, while environmental goods remain in fixed supply, it is expected that prices for environmental goods will rise. This was hypothesized in 1967 by Krutilla (49), and shown in a general equilibrium approach (1972) by Smith (76). Furthermore, as stated by Smith, ". . . irreversibilities will add to the increase in the relative price of amenity services" (76, p. 86). Technology is expected to provide alternatives at Hell's Canyon to the developed site. For example, advances are expected to be made in electricity generation, such that the Hell's Canyon development value for electricity will decline relative to alternative sources of electricity. Hence, as time goes on, embodied technical change is likely to cause future development benefits to be low although the first year may be high. Conversely, present environmental benefits may be low but they are expected to grow over time with increased populations and tastes. Under specific assumptions it was shown by Krutilla et al. in the Hell's Canyon study that low environmental values today that grow



over time do not need to be large to compete with declining development benefits when both are converted to present value. It was concluded, subsequently, that recreation benefits in its present use were more than sufficient to compete with developmental benefits.

Difficulties of the model, however, as specified by Krutilla et al., need also to be considered. Aside from the usual problems of specifying assumptions to be made in estimating future trends of technical change, population growth, changes in tastes, carrying capacities, terminal years, and so on, there is the additional problem involved with discounting to calculate present values, especially where recreation and environmental benefits are involved. A basic question which Krutilla et al. did not address is whether or not environmental quality benefits should be discounted to a present value using a positive interest rate, the same rate used to discount development benefits. However, the need to address the problem of interest rates was not necessary in their case. They amassed sufficient evidence to show that preservation benefits are more than adequate to offset development benefits using the same discount rates for both.

Can this general technique be adopted to the problem exemplified by the Ames Reservoir? Initially, the model appears to have considerable relevance. First, the Ames Reservoir project as planned by the Corps is incompatible with environmental amenities that accrue from the resources that will be flooded. Second, there appears to be some evidence that environmental values are

positive. For example, a recreation use survey in 1972 estimated about 12,300 summer activity days in the region of McFarland's Park, Soper's Mill Access, and "other site areas" (15, Table 3-1-3). Third, there exist technological alternatives to flood control by dam storage, water quality control by low flow augmentation, and reservoir-based recreation. Fourth, it appears that alternative development benefits can be partially or completely calculated, although it may be difficult to spell out "technical change" at x percent a year in flood control.

Potential thus exists to calculate amenity and "green belt" recreation benefits, growing at specified rates relative to changes in tastes and populations, calculated over an expected life of the project, aggregated, and discounted to obtain a measure of present value. Likewise, reservoir benefits can be calculated. Study of the situation, however, renders the exercise for the Ames Reservoir unnecessary at this stage since alternatives to meet desired project objectives such as flood control exist at present which have been overlooked, or inadequately considered, in the project formulation.

#### Benefit Estimation by Environmental Improvement

This fourth general approach is very basic. The market value of environmental benefits is estimated by determining the value of goods and services resulting from environmental improvement. A recent application of this technique is by Lave and Seskin (51) who attempted to quantify the monetary benefits resulting from

improved air quality. They estimated direct and indirect costs of disease, treatment, health activities, and earnings foregone by those who were sick, disabled, and prematurely dead. They concluded that 4.5 percent of all measurable economic costs associated with morbidity and mortality would be saved by a 50 percent reduction in air pollution in major urban areas.

Although the value of earnings foregone as a result of morbidity and mortality provided a gross underestimate of the amount society is willing to pay to lessen pain and premature death, no other way seemed to exist for them to derive numerical estimates. They conjectured that the major benefit of pollution abatement will be found in a general increase in human happiness or improvement in the quality of life, rather than the more easily measurable "hard" costs. Therefore, their estimates were gross underestimates of real societal benefits.

With respect to water, benefits resulting from increased water quality can also be measured. Recent studies, by Seay (73) focusing on sediment in water courses, by Jacobs (45) who added phosphorous, and Spies (77) focusing on institutional efficiency, calculated least cost means of achieving specified water quality levels in rural stream areas. Benefits can be quantified, for example, by calculating reduced treatment costs of water supplies for municipal organizations. These can be compared to the costs to agriculture of reducing stream sediment and phosphorous loads. Again, however, these studies have not estimated the aesthetic

and amenity benefits of improved water quality, benefits which might be significant.

An alternative approach to estimating benefits is to use regional models which attempt to maximize community income subject to specified levels of "pollutants" and restraints on industrial employment to restrict employee hiring and release. This approach was taken by Beck (8) who used a combination of input-output and linear programming models to maximize regional income. Trade-offs between water quality levels and income were calculated, which revealed various benefits and costs. Still, however, aesthetic and amenity benefits resulting from improved water quality were not considered as a use.

These models relating to water quality serve the maximum GNP productivity criterion by calculating least cost means of achieving specified water quality levels. But how are the water quality levels to be specified? If the only uses of water were uses in which monetary costs and benefits could be identified, that level of quality where net benefits are maximized would be the recommended level since GNP would also be greatest. However, if aesthetic and amenity uses exist which cannot be monetarily priced, optimal quality levels of water cannot be specified. The use of shadow prices, from dual solutions of mathematical programming models, would indicate directions of movement for the objective function when resource levels were altered but, again, the level of resources such as water quality available to the optimizing process

must somehow be specified. Such specification can arise through the use of an opportunity cost approach, in which trade-offs between levels of quality and cost savings or benefit gains are compared. Such comparison, however, is outside the realm of the maximum GNP criterion since prices are now not assumed given by forces of monetary supply and demand.

The use of price proxies, as in the following example, is similar. Suppose, for example, the number of forest acres saved by not building the Ames Reservoir is used to obtain a price per acre by dividing the net benefits of the project by the number of acres. But whether the project should be built or the forest preserved cannot then be decided by the GNP criterion. It is up to the broad productivity criterion, a trade-off process, in which it is decided if the price for saving the trees is too high in terms of foregone development benefits, assuming that operation is on the production-possibility frontier. In summary, benefit estimation by environmental improvement appears to be of limited relevance to the problem posed by reservoir inundation. Major benefits of the present situation are expected to be those related to non-priced environmental amenities, benefits these models cannot estimate.

#### The Role of Interest Rates in the GNP Criterion

Not yet considered in this chapter is the role played by interest rates to discount monetary returns and costs accruing

in future time periods so that comparison of present equivalent values can be made to decide directions of investment. Monetary benefits can be estimated by methods described in this chapter for imputing market values by indirect and non-market techniques. This section deals with the problem of interest or discount rates used in the application of the maximum GNP productivity criterion where benefits and costs accrue in different time periods.

Economists connect time periods through the use of the rate of interest. Commonly used is the expression of the present value of a future stream of income. Present value is the amount that would need to be invested today to return a stream of income in the future equivalent to the yield of benefits of a project in question. The interest rate (discount rate) measures the opportunity cost of capital by determining the sacrifice that is made by not investing in the present. However, the market-determined interest which if, as stated by Prest and Turvey (67, p. 697), "neo-classical theory is accepted and a perfectly functioning capital market assumed", may be inadequate in the social sphere because it ignores the time preference of individuals and societies.

Time preference represents a second component of the interest rate. Prest and Turvey (67, pp. 697-698) refer to time preference in consumption and investment as the "social time preference rate" of interest. The opportunity cost of capital, equivalent to the marginal productivity of investment in a perfectly functioning neo-classical capital market, is termed the

"social opportunity cost rate" of interest.<sup>1</sup>

The social time preference rate is important in the field of environmental quality. Many parks are created, not only to provide an arena for recreation (which can also be supplied privately), but to preserve "natural wonders" for future generations to enjoy as the present generation does now. By restricting development, present consumption is foregone to provide for the future. As stated by Arrow, "The welfare interpretation of interest rates requires that they correspond to time preference on the part of individuals" (2, p. 17). Much concern about environmental quality appears to involve future consumption of amenities.

Pigou, after discussing people's myopic preferences for the present in reference to the future, stated that (66, pp. 29-30):

. . . the State should protect the interests of the future in some degree against the effects of our irrational discounting and of our preference for ourselves over our descendants. . . . It is the clear duty of Government, which is the trustee for unborn generations as well as for its present citizens, to watch over, and, if need be, by legislative enactment, to defend, the exhaustible natural resources of the country from rash and reckless spoliation.

Pigou argued that taxes and subsidies should be used to encourage investment which will return benefits only in the future, beyond what our defective "telescopic faculty" can perceive.

Marglin (54), however, points out, as reviewed by Mishan (59, pp. 210-214), that a social rate of discount below the

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<sup>1</sup>This study does not address the problem of determining empirical measures of the social opportunity cost rate. The problem is dealt more fully by such writers as Marglin (53, 54) and Baumol (6) and the references contained therein.

equilibrium rate of interest thrown up by a competitive economy can be justified only in the presence of external effects. In this case, the particular type of external effect involved, one with public good characteristics, is "one arising from the experience of welfare at the thought of additional consumption of future generations" (59, p. 211).<sup>1</sup> Mishan notes, however, that this notion appears to be at variance with the familiar distributional judgment which favors the transfer of income from rich to poor both within, and between communities. Since future generations are likely to be richer than the present, it seems irrational to Mishan to support a lower social discount rate than the competitive rate. Now, however, Mishan has overlooked the problem of irreversibilities, a problem which was foreseen by Pigou, and many other writers including Baumel (6), and especially Fisher and others at *Resources for the Future* (30). As stated by Baumel, ". . . all the wealth and resources of future generations will not suffice to restore them" (6, p. 801).

Returning to consideration of the *Resources for the Future* study of alternatives at the Hell's Canyon, the researchers employed discount rates of 8 to 10 percent for discounting the stream of benefits from both preservation and electricity development

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<sup>1</sup>Other factors, as pointed out by Marglin (53, pp. 194-197), include that even if a person wishes to reduce his premium on current consumption, he will only do so if his sacrifice is matched by other sacrifices in the community. Also, the degree of concern for future generations may generally be too low to be operative in the competitive market. Marglin also argues that Pigou's interpretation is a fundamentally authoritarian one in a democratic society.



alternatives. Use of the competitive rate rendered symmetrical analysis in the comparison of the two incompatible alternatives. Nevertheless, it is interesting to note a significant aspect of discounting which is relevant in the study of amenities. This corresponds to the notion that discount rates should possibly be zero, or approaching zero (even negative), when matters of environmental quality, and possibly recreation, are involved. This notion brings up the problem of multiple discount rates, one for different types of investment, both public and private. Due to its potential for subjectivity, multiple discount rates are not generally explored in the literature.

Marglin, again, is one exception (55). Commenting on the 1971 revision of the Water Resources Council's proposed principles and standards for planning United States water and land resources (90), Marglin objects to the use of the opportunity cost measure of the discount rate, as presented in the draft statements. First, this requires an optimal economy, and second, it requires equal time profiles between private and public sectors. The social time-preference has been ignored by the Water Resources Council for inter-temporal comparisons. This is of "serious nature", especially upon the recognized achievements of the 1970 and 1971 documents (89, 90) in granting legitimacy and bringing to par with national economic development other objectives such as environmental quality. To correspond to the multiple-objectives of society, he suggests the use of spectrum rates, not single discount rates as is the

common practice now and to be continued in the future. For example, three discount rates could be used: low, medium and high. A low rate, however, with respect to one objective may not be a low rate in regards to another. As stated by Marglin (55, p. 22):

For example, a low rate for national economic development might be two and a half percent but for environmental quality zero, which would indicate that the relative emphasis on future environmental quality should be higher relative to the present than it is with respect to national economic development because of the expectation that the problems of the environment are going to get more serious as time goes by and not less.

Further, a high set of rates might be seven and a half for national economic development, five for environmental quality and ten percent for regional development and social well-being.

In this way, Marglin seeks to emphasize the social time preference rate over the social opportunity cost rate in matters of environmental quality. However, there is even the question whether or not amenity values accruing in the future can be discounted to present values with positive rates of interest. A basic purpose of preserving natural resources is to ensure that the supply of amenity services can be maintained for future generations to enjoy. Since benefits are demanded in the future as well as in the present, discounting may be irrelevant in the case of future amenity benefits.

In the introduction to this study, recreation, aesthetics, and amenities were isolated as one of the major demand classes of society. Using the concept of "drives", as advocated by Roberts

and Holdren (68, pp. 25-30), persons are most likely stimulated to consume recreation and amenities at fairly regular intervals during a lifetime. People may possess a drive to partake of recreation regularly in the outdoors, or may wish to enjoy the amenity pleasures of a forest continuously throughout life. Indeed, a rational person is expected to spread out his consumption of recreation and amenities over time. He likely cannot consume a "life's" worth of benefits in one glorious month, and then do without for the rest of his life, a desired time stream of consumption not accommodated by discounting and present values. Many different kinds of income streams can result in equivalent present values (including one lump sum in a future time period).

There is also the problem and possibility of irreversibilities since, once destroyed, a particular "gift of nature" may not be able to be replaced in the planning horizon of a society, even over several or many centuries of time. Once the benefits flowing from such resources are foregone, they cannot be reobtained.

Amenity benefits are likely to be demanded for consumption in the future. Converting future benefits to a present value using a positive rate of discount fails to distinguish that all benefits are not demanded at present for current consumption.

It therefore appears that the relevant discount rate for discounting future environmental quality benefits to obtain a present value, for the purpose of converting all future benefits to one point in time to compare alternatives, is the use of a zero or

near-zero (to accommodate inflation) discount rate to reflect time preference. However, this implies that a monetary value can be placed upon the benefits flowing from the resources. If such is impossible, discounting at a zero rate is meaningless. An analyst might in such cases prepare side displays of information, which cannot be monetarily quantified, to those which enter standard benefit-cost calculations. Such side displays of information appear to represent the use of a time preference rate of discount since they represent benefits which will accrue in the future, but which must be evaluated and compared in the present. However, the criterion of economic performance now being used instead of maximizing GNP is that of the broad productivity criterion.

#### Model Choice for Application of the GNP Criterion

In order to apply the maximum GNP productivity criterion in this study so as to incorporate environmental quality as a social objective, it was decided that a willingness-to-pay model, adapted from the economic literature of outdoor recreation, was best suited of all the methods discussed in this chapter. In particular, such a model can provide an estimate of the demand curve which may then be used to provide revenue estimates, avoiding the consumer surplus controversy. The method chosen uses direct interview techniques to determine estimates of willingness to pay in terms of travel costs to visit a green-belt park system, or aiding financially in

its establishment. The green-belt park system would encompass lands otherwise to be inundated by the Ames Reservoir, and would be expected to preserve the amenity values of the area. Use of a zero or near zero rate of discount will aid in ensuring that future time preferences of society are met.

It is therefore assumed that institutional changes are possible which will allow the green-belt park system to be brought into existence if the green-belt can be shown to be a feasible investment project. This assumption is necessary in order to provide realism to the application of the maximum GNP criterion in this study.

The next chapter focuses on the more general member of the two productivity criteria, namely the broad productivity criterion. To maintain the discussion in a two-dimensional framework, the two social outputs considered are those relating to amenity services at the Ames Reservoir site and the expected outputs of the project, as measured by net monetary benefits if the project is built. These can be considered as the general social objectives or "goods" of economic development and environmental quality. If the production frontier can be identified, society's present position can be determined. It is noted that the present position of society is most likely not on the frontier, because all technical means of achieving output have not been considered by society planners. Hence, the maximum GNP criterion may not even be required to choose the "best" Pareto optimal point on the frontier. Only on

the frontier is it impossible to achieve more of one "good", either economic development or environmental quality, by restructuring production while holding output of the other constant. If it can be proved that it is possible to increase output of one "good", while holding the level of production of the second at a constant level then, without calculating any price-quantity sums, it is desirable for society to move in the direction of increased total output, termed a Pareto-better move for society. This is now more fully developed in the next chapter, where the final model is also developed for application in this study. This model attempts to determine aspects of the nature of the production-possibility frontier, in addition to suggesting a particular combination of outputs of development and environmental quality employing the maximum GNP criterion and a willingness-to-pay technique.

## CHAPTER IV. MODEL DEVELOPMENT

The previous chapter discussed alternative methods for obtaining price-quantity measures which could be used to incorporate environmental quality into the GNP criterion. This chapter focuses on the other pair of the two productivity criteria, the broad productivity criterion. The chapter concludes with the development of the model used in this study. The model attempts to include both criteria in the natural resource evaluation process since, as discussed in Chapter II, neither is fully satisfactory by itself.

The chapter begins with a discussion of the production-possibility frontier in a multiple social objective framework. The basic purpose is to determine the shape of the production frontier, and society's present position in the production space. However, the achievement of a point on the frontier appears to be impossible if institutional rigidities or other restraints exist. Without knowledge of prices, utilities, or the production-possibility frontier, it seems desirable to seek evidence which will permit a Pareto-better redistribution of social output if society is not on the frontier. A Pareto-better redistribution is said to occur when more of one output can be obtained by reorganization of production without reducing the amount of other outputs produced.

To analyze whether a Pareto-better move is possible in practice and reality, it is essential to determine how the two social outputs of concern in this study, goods and services from economic development and environmental quality, are to be measured. In

this study, it was assumed that economic development goods and services could be measured by the net benefits from benefit-cost analysis. This places a common denominator of monetary values upon diverse goods and services. In regards to environmental quality, this chapter devises a technique for the measurement of amenity services in the land to be inundated by reservoir construction. In devising the technique employed in this study, a detailed discussion is included of two existing comprehensive methods for the preparation of environmental impact statements, as required under the 1969 National Environmental Protection Act (68).

#### Production Criteria and Economic Welfare

Production criteria were introduced in Chapter II. This section expands on that discussion with particular focus on the production space itself rather than on the Pareto efficient points located on the frontier. Purely technological relationships are considered, without the use of any money forms of measurement.

Following the exposition of Graff (34) the only value judgment required in this analysis is that more of any output, or less of any input, is, *ceteris paribus*, a good thing. Production is said to be organized optimally when society cannot get more of any one output without sacrificing other outputs or expending additional inputs, and cannot use less of any one input without using more of other inputs, or sacrificing outputs (34, p. 14). In a simple two output world, a locus of such optimal points is presented as TT in Figure 4-1. This curve can be called the social transformation



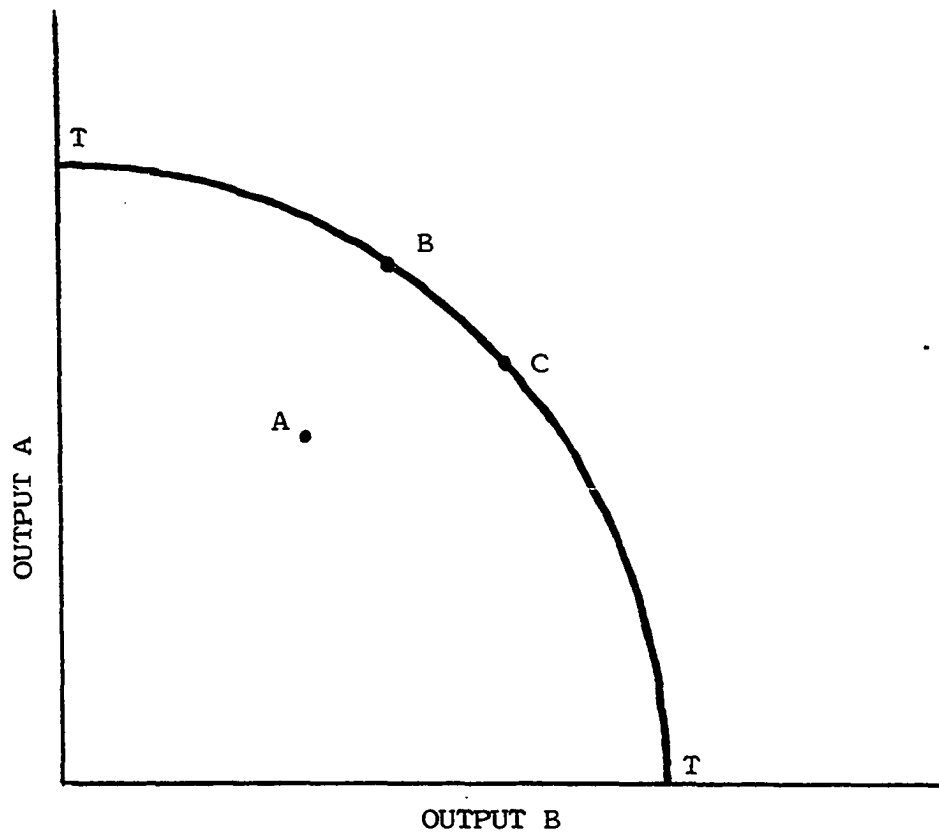


Figure 4-1. The production-possibility frontier

function (34, p. 15) since it describes society's potential production powers. It is the same curve entitled the production-possibility frontier in Chapter II, the term used in this study. It describes the technological knowledge available to society. The area under the curve and enclosed by the two axes is termed the production space. Conceptually, the discussion is analogous but much more complex in a multidimensional framework.

If all goods and services can be included in the analysis, and more is always desired to less, it is impossible for a society to be Pareto optimal unless it is also Pareto efficient by operating at some point on the frontier. Operation of an economy was said to be Pareto optimal if it is impossible to make some member better off without reducing the utility of some other members. Thus, at point A in Figure 4-1, by reorganizing production, more of one good can be obtained without sacrificing the level of the other. There is subsequently more total output, and more utility to distribute so that some people can be made better off without harming others. Hence only if society is operating somewhere on the production frontier is it possible to have Pareto optimality. However, not every point on the frontier is a Pareto optimal organization of society, as pointed out by Dorfman and Dorfman (28, p. xxvi). The wrong combination of outputs could be produced. It depends upon the utilities provided by the outputs. Utility may be enhanced for some members without sacrificing the level of utility of others, by moving from B to C on Figure 4-1.

With reference to this study, consider the outputs arising from amenity services and achievement of economic development as measured by GNP. Labeling these outputs as environmental quality and economic development respectively, a similar interpretation of Pareto efficiency is possible as follows. If social indifference curves derived from a social welfare function were everywhere continuous and convex to the origin, as shown by  $W_1$  to  $W_4$  in Figure 4-2,

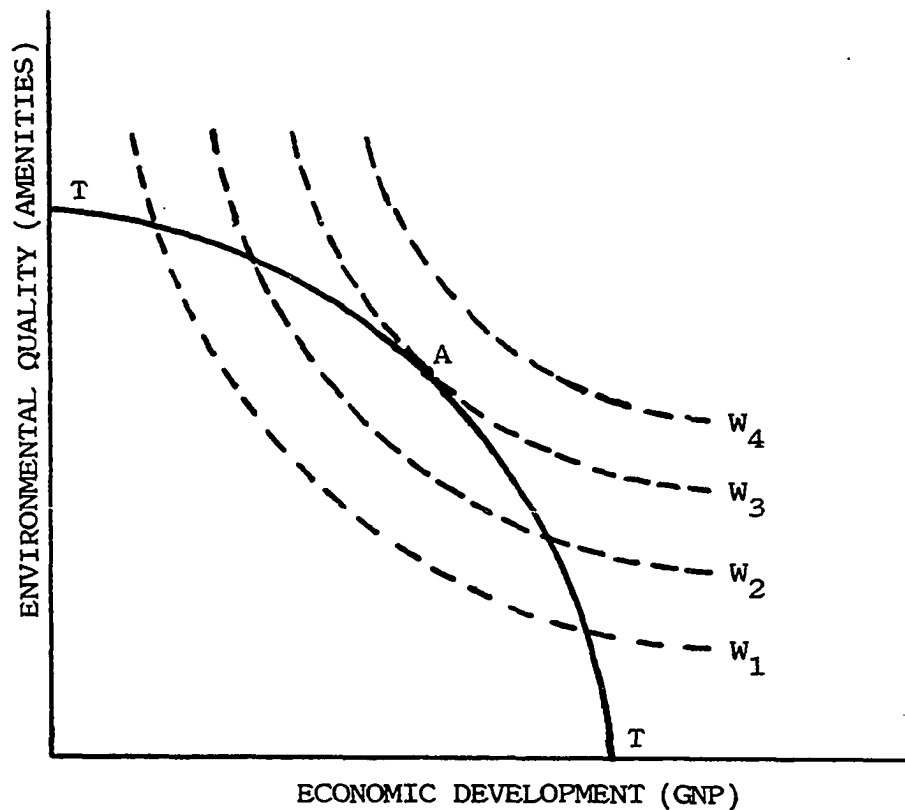


Figure 4-2. Social indifference curves

the optimal distribution of the two outputs, namely environmental quality and economic development, would be at the tangency, A, of the highest social indifference curve with the production-possibility frontier, TT. No reorganization of production is possible in this two-output world that will enhance social welfare given the shape and existence of these curves. In the diagram, the concavity of the production-possibility frontier is predicated on the assumption that more output from development must create a

decline in the quantity or quality of output obtained from environmental amenities. At the point of tangency, the slope of the curve represents the marginal social rate of transformation of environmental quality into economic development.

A similar multi-objective framework is that shown by Cobb, and discussed by Haveman and others (20, pp. 103-109), with reference to net national income and net regional income as the social objectives. Cobb argued that a more nearly optimal investment program may be attained by designing projects and programs explicitly in terms of all relevant objectives, rather than by designing them in terms of a single objective and then taking other objectives into account with ad hoc adjustments. Cobb used net benefits for axis measurement since net amounts are desired rather than gross benefits or gross output. If a project is designed for two objectives, the highest social value will occur with the tangency of the "net benefit transformation curve" with the highest social indifference curve.

In the every day world, however, a less ideal approach must be followed because the shape of production frontiers are usually unknown, as are the social indifference curves. Since the world is continually adjusting to changes in tastes and demands, technology, and resource supplies, the static concept of Pareto efficiency is of limited practical application. Instead of focusing on the ideal, it seems necessary to recognize the practical problems of resource allocation in the absence of social welfare

functions and knowledge of frontiers, including the rigidities created by institutional structures and government.

Graff also recognized the existence of institutional structures, realizing that in practice a society will find itself well within the production frontier. That is, sub-optimal situations will usually be the only feasible ones (34, p. 75). However, as evidenced in Chapter I and Appendix E, the institutional system appears to be malleable and subject to change. The feasibility of achieving a particular point in the production space will vary as institutions are altered. As stated by Graff, "If we regard the institutional framework inherited by society as malleable and subject to extensive alteration at will, the welfare frontier is attainable and therefore relevant" (34, p. 83).

To summarize, it is still correct to strive to achieve points upon the production-possibility frontier if it is possible to alter extensively the existing institutional framework. Since institutions were created by man they can also be changed by him at later periods. It is therefore useful to attempt to locate the frontier, to identify society's present position in relation to the frontier, to suggest institutional reform necessary to move from points within to points upon, and, in the absence of a specific welfare function, to identify weights (prices) associated with outputs so that points of increased social welfare can be identified. If weights or prices cannot be identified, at least a Pareto-better

move is preferred. Such a possibility needs to be explored, in the minimum. It is to these tasks which this chapter now turns.

### Measurement of the Economic

#### Development Axis

Of first importance is measurement of the two outputs, environmental quality and development, under consideration in this study. Net monetary benefits from development projects appear to constitute a relevant scale for development measurement as is now discussed.

The conventional approach for calculating net monetary benefits in the water resource sphere is with the use of benefit-cost analysis.<sup>1</sup> That is, total gross costs are subtracted from total gross benefits to yield net returns from a project. The greatest net benefits will result in the maximization of GNP, as discussed in Chapter III. Eckstein (29) and Marglin (53), in addition to Mishan (59), have shown that under assumptions of perfect competition but with budget constraints projects should be constructed in order of the magnitude of their benefit to cost ratios, largest first. Difficulties result when comparing projects with varying operating over total capital ratios and between different public services. Other problems exist in measuring benefits, choosing appropriate discount rates, and determining

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<sup>1</sup>In a private economy net benefits are equivalent to net profit from a firm which produced the same commodities.

length of life for projects. These difficulties aside, however, it was assumed that the appropriate measure for the development axis is the net benefit flowing from the project since these benefits are generally accepted as a criterion to determine the worthiness of alternative projects, especially in water-resource planning.

Benefit-cost analysis in its pure form is applicable to only one social goal. This is the goal of maximizing GNP from the given stock of resources available. This goal is defined solely in terms of efficiency--where efficiency is the maximization of a price weighted sum. Such a sum exists in the total value of priced final goods and services or GNP in practice. Where other social objectives exist, however, such as income distribution, preservation of environmental and cultural amenities, social well-being such as justice, freedom, and other standards of social quality, the goal of efficiency becomes bounded by restrictions. In effect, the resource stock available for application of the efficiency criterion has been reduced in size because certain resources have been conscripted to meet specific social programs and outputs.

Further complications arise because of market defects such as monopoly, increasing returns, and public goods and externalities. Such defects, even if the efficiency criterion were the only one, render the criterion impossible to be maximized.

Theoretically, if one wishes to estimate the shape of the production-possibility frontier relating the outputs of development versus environmental quality, the national region is the

logical framework of reference for the development axis. Since the present investment under consideration is being planned by Federal planners, using Federal funds, and since there is nothing in the plan of the Ames Reservoir dealing explicitly with income distribution, it seems reasonable to assume that benefits of outputs will flow to the nation as a whole. For example, the net benefit flowing from additional production due to flood control can readily be incorporated with national total product. The same can be said for the recreation benefits if it is assumed that they measure the true market value.

Water quality, a third project objective, is less clear, however, in considering its contribution to GNP. In the original calculations of the Corps of Engineers, the alternative cost concept was employed to obtain a measure of monetary benefits. This concept is allowed to be used when benefits are unknown or cannot be calculated. According to the "Green Book", in the absence of an adequate competitive market the expected cost of production by the most likely alternative source that would be utilized in the absence of the project may serve as a basis for measuring the value of goods and services (87, p. 9). Therefore, benefits can be assumed to be at least equal to or greater than cost of the alternative. Because of some conceptual problems in this approach, however, there is the basic problem of whether these benefits can legitimately be added to the stock of other monetary benefits which are derived in a more market-oriented framework such as



flood control benefits.

The problem arises as follows. Focus is on the validity of use. If there is 100 percent certainty that a project will be built to meet a certain demand, then benefits are at least equal to or greater than cost. If a second alternative, cheaper than the first, is discovered, then a minimum level of benefits equal to the first can be given to the second, resulting in a benefit-cost ratio greater than unity. This procedure is conceptually valid when the first will be built with certainty. But now the exercise is trivial and adds no information since simple cost-effectiveness or cost minimization would do the same without conjuring up imaginary benefits.

On the other hand, as applied by the Corps in their estimation of water quality benefits of the Ames Reservoir (81), the proviso of 100 percent certainty for the alternative does not exist. They use a single-purpose reservoir for water quality storage as the alternative. That is, if the multiple-purpose project will not be constructed, the single-purpose project will be constructed in its place. This in all likelihood is not expected to happen. Hence the benefits obtained for water quality can be considered to be invalid. In addition the concept can be easily abused since one can most always hypothesize a higher cost alternative. For how is the single-purpose reservoir to be justified? One way is to seek a third higher cost alternative. Such a step procedure appears to have no end.

The alternative cost method uses no market derived base for the measurement of value. For example, no attempt was made to estimate demand or the absolute merit of either the water quality component of the Ames Reservoir Project or the single-purpose water quality reservoir. This was avoided by assuming 100 percent certainty of construction, a questionable assumption. On the other hand, if stream quality standards are to be met, the purpose of the planner should be to minimize costs for comparing alternatives, not to estimate benefits.

Despite these difficulties and since estimation of flood control, reservoir recreation and water quality benefits was not the basic purpose of this chapter or thesis, it was therefore assumed in this study that all net benefits calculated by the Corps of Engineers could be used as a measure of the social output of economic development resulting from construction of the Ames Reservoir.

#### Measurement of the Environmental Quality Axis

Development as discussed in the previous section can be measured by the calculation of net monetary benefits which accrue to the nation as a whole from project construction. Each point on the development axis represents an alternative combination of project inputs and outputs, measured in a common unit of dollars. Although not a true physical scale of measurement since it is expressed in dollar units of the good or service rather than the

number of bushels, visits, or dams, it is useful since it measures investment output.

While economic development alternatives can be measured by their contribution to GNP, no national social accounting tool, which could be termed gross environmental quality, GEQ, exists as yet for the measurement of environmental quality. A different approach is therefore required and now developed for use in this study.

As in conventional goods and services, it is necessary to determine the physical units of the environmental good or service involved. In environmental quality, identification appears necessary of specific physical impacts that development will have upon the environment. In the case of a reservoir, it involved identification of the types of natural resources that will be flooded, plus the physical magnitude of the project upon each resource category identified. With reference to the proposed Ames Reservoir, an inventory is subsequently required of all the natural resources that would be affected by the project. Ideally, this could be done with the consultation of specialists in various natural and social sciences, in addition to surveying the general public in order to uncover additional uses of the area that might exist. For each project and alternative scale of development an inventory would be required of the physical impacts of the projects upon natural resources in the region.

Such an inventory could conceivably account for a millenary of

impacts of a project by accounting for each tree, animal and insect. Hence, an immediate value judgment required is the degree of detail necessary in the inventory. This is a function of many factors, especially time and money budgets. A guide is therefore required for aiding in the inventory of project impacts. Such a guide exists in the researcher's or the research leader's value judgment(s) as to what is thought of potential amenity value to the public in general. The consideration of public values leads then to the search for "broad" categories (depending on inventory budgets) of impacts such as general types of forest or wildlife that would be flooded. For each type the physical impact of the project would have to be determined.

If such an inventory were completed it would be sufficient in order to obtain a production-possibility curve, which, however, might not constitute the frontier since not all production possibilities may have been considered. If only one impact were encountered a production-possibility curve could be immediately derived. On one axis would be the net benefits from alternative scales of development, on the other would be the physical impacts in the relevant scale of measurement, such as numbers, acres, et cetera. However, if more than one category of effects were determined, a method needs to be found for aggregating across categories in order to obtain a composite index which would serve as the measure for the environmental axis. Otherwise, the alternative is to develop a production-possibility curve for each category.

Then, at least in theory, that scale of development would be chosen where, if a social welfare function were available, social welfare would be maximized.

Aggregation appears necessary to derive a production-possibility curve that includes all environmental categories on one axis. Such a curve would identify trade-off possibilities under the present institutional arrangement. It would not, however, constitute the production-possibility frontier since, as mentioned above, not all production possibilities have been considered. For example, the additional bushels from reduced crop damages by flood control could possibly be obtained by upstream soil conservation measures. Additionally, for productive efficiency to occur by reaching points on the frontiers, as discussed in the first section of this chapter, institutions must be considered malleable. This may not be the case in the present situation because the Corps of Engineers are authorized only to build flood control structures, not study soil conservation possibilities.

Means of aggregating are now discussed in order to obtain one index which will measure overall environmental impact of alternative scales of development. The method employed is to review two major aggregation techniques in the preparation of environmental impact statements, one as suggested by Leopold et al., for the U.S. Geological Survey.(52), and the other as developed by Dee et al. of Battelle Columbus Laboratories (27). These two techniques, in

addition to theory presented in this and previous chapters, provided suggestions for development of the model employed in this study.

#### The Leopold Matrix

In a report published by the U.S. Geological Survey, Leopold et al. devised in 1971 a procedure to assist in the development of uniform environmental impact statements (52). The heart of their system is a matrix which can be used as a reference checklist and as an abstract of the text of the environmental assessment. One dimension of the matrix contains a list of actions that can result in environmental impact. The other dimension contains a list of environmental characteristics that can receive environmental impact. Each list can be expanded or contracted depending on the individual nature of the project being considered. The list of actions includes general activity categories such as modification of regime, land transformation and construction, resource extraction, processing, land alteration, resource renewal, and so on. Each category is divided into more specific areas. The list of broad environmental characteristics that can receive impact include: 1. physical and chemical characteristics of earth, water, atmosphere and processes; 2. biological conditions relating to fauna and flora; 3. cultural factors affecting land use, recreation, aesthetics and human interest, cultural status, and man-made facilities and activities; and 4. various ecological relationships. All told, the sample matrix as suggested by these authors contains 100

activities and 88 environmental categories.

Given the matrix, the procedure suggested for its use in assessing environmental impact is as follows. First, identify all actions (located across the top of the matrix) that are part of the proposed project. Then, identify in the action columns each cell which represents the interaction of the impact of the action (activity) upon a specific environmental category (listed as rows on the left side of the matrix). Each of these cells is then evaluated individually by entering two numerical indicators which signify the magnitude of the possible impact and the importance of the possible impact. Considering only adverse impacts, an index on a scale from 1-10 is employed as a measure for each of magnitude and importance. The number 1 is used to represent the least possible magnitude and the least possible importance while the number 10 represents the greatest possible magnitude and importance.

The order of magnitude is determined first. Generally, this can be conveniently thought of in terms of degree, extensiveness, scale or percentage. For example, if a project will destroy 20 percent of a grove of trees, the number 2 can be inserted as the order of magnitude. If all the trees would be destroyed the number 10 would be entered. Magnitude is basically straightforward and objective to determine by specialists in the required fields. However, as Leopold et al. fail to point out explicitly, the region of impact must be precisely defined in order to measure the

magnitude. This immediately involves a value judgment which, however, can be deferred to consideration of importance values by arbitrarily choosing a region of impact such as measures of area, length and volume (a square mile of land, a reach of a river, the air over a city).

The second major step is determination of importance of possible impacts. According to the authors, "The importance of each specific environmental impact must include consideration of the consequences of changing the particular condition on other factors in the environment. . . . Unlike magnitude of impact, which can be more readily evaluated on the basis of facts, evaluation of the importance of impact generally will be based on the value judgment of the evaluator" (52, p. 2). Herein lies a main source of conceptual difficulty. First, the relevant region of consideration must be decided. It could be local, county, state, river basin, or even national in size. A second value judgment lies in the choice of the degree of importance in the range of 1-10. Leopold et al. suggest that only the evaluator make the judgment of importance and thereby select the relevant weights. Now, however, the evaluator's bias/biases is/are allowed to enter, reducing the objectiveness of the method. His weights may not reflect social weights.

Finally, as described by Leopold et al., the text of an environmental impact statement which accompanies the matrix should be a discussion of the significant impacts, those columns and



rows with large numbers of boxes marked, and individual boxes with the larger numbers. The text should primarily be a discussion of the reasoning behind the assignment of the numerical values. This allows project reviewers to follow the originator's line of reasoning and aid in identifying points of agreement or disagreement.

A final value judgment, not mentioned by Leopold et al., is that of deciding when the overall environmental impact is of sufficient size so that the environmental cost is greater than the stated benefits of the proposed project. This requires knowledge of societal preferences, which in the absence of specific information as to a social welfare function, must be obtained from the informed judgment of some person or group in power of allocating social resources. Since this problem is not addressed, Leopold et al. do not progress further than isolation of a series of trade-offs.

Additionally, they do not provide a precise scale of measurement for use in an environmental axis. Indeed, they emphasize "that no two boxes on any one matrix are precisely equateable" (52, p. 6). This statement, however, cannot be true if the matrix is to have consistent meaning. If identical numbers in different cells or boxes cannot be considered as relative equals then the entire matrix is shaky and the numbers are suspect throughout. If, however, the numbers are assumed to have consistent meaning in the matrix, which they should if one evaluator assessed all the importance values, then the matrix can be used to obtain an

aggregate measure of environmental impact. This could be done by multiplying the magnitude and importance values in each individual cell and summing over all the cells in the matrix to obtain a grand index of environmental quality. Such a grand index can be used as one point on the environmental quality axis in constructing a production-possibility curve. Additional points could be obtained, and a curve traced out, for the objectives under consideration by varying the scales of project and then determining the effects on the grand index of environmental quality. Certain assumptions are important. One is that the dimensions of the matrix remain unchanged. Another is that the evaluator does not alter the relative scale of index values placed upon measures of magnitude and importance. If either assumption were violated, the index would be like measuring objects with a rubber band.

In summary, although the Leopold matrix can be criticized because it appears to be more of an inventory than evaluation scheme, and the value judgments for importance are made by the evaluator, the technique has several advantages. It is systematic. It is basically simple to understand and apply. It may be used in very general or detailed situations. Finally, it can be adapted to the derivation of an aggregate index of environmental quality as illustrated in the previous paragraph.

The next section discusses a second, more comprehensive, approach to the preparation of environmental impact statements. Nevertheless, it still shares certain common features of the Leopold matrix in terms of strengths and weaknesses.

### The Battelle EES

In a report to the Bureau of Reclamation, U.S. Department of the Interior, Battelle-Columbus Laboratories, under the authorship of Dee et al., summarized a model and test results of an environmental evaluation system (EES) for water resource planning (27). In the report, a system was described for use in evaluating environmental impacts of Bureau of Reclamation projects. According to the authors, it is a method of quantifying the environmental impacts of water resource development projects with respect to ecology, environmental pollution, aesthetics and human interest. Measures of impacts were expressed in environmental impact units, a measure of aggregated environmental impact which identified trade-offs.

Their procedure can be summarized as follows: For each of the four above components, specific parameters were identified, seventy-eight parameters in total. The eighteen parameters in ecology included such items as natural vegetation, fish, and rare and endangered species. The component of environmental pollution was subdivided into twenty-four parameters in the four categories of water, air, land and noise pollution. For example, parameters in water pollution included dissolved oxygen levels, BOD and coliforms. Other parameters were identified in the two remaining broad components, seventeen in aesthetics and nineteen in human interest.

For each parameter, a "value function" was developed in order to define environmental quality. The number 0 denoted very bad

quality and 1 very good quality, with a continuous range in between. This converted all values into a common base. The shape of the curve relating environmental quality (0 to 1) to parameter scales of intensity was then obtained from measurement data.

The Battelle value function is basically similar to the meaning of magnitude as used in the Leopold matrix. It measures the physical impact of the proposed project. The difference is that Battelle used a continuous ordering from 0 to 1, while Leopold et al. used a 10-point scale, which could easily be transformed into a 0 to 1 basis.

The Battelle EES method also recognized that some parameters are more important than others, as reflected by the importance measures in the Leopold matrix. Consequently, parameter weights were devised by Battelle to reflect relative rankings. Leopold et al. used weights of 1 to 10, where 10 represented the most important. On the other hand, Battelle arbitrarily chose 1,000 points, and divided them among the 78 parameters using socio-psychological scaling techniques (ranked pair-wise comparisons) and the Delphi technique.<sup>1</sup> The group whose value judgments were

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<sup>1</sup>For a detailed discussion of the Delphi procedures see Dalkey et al. (24). The Delphi technique is a procedure which employs a group response to determine information about particular areas of interest in which exact information is unknown. It has statistically been shown that use of the Delphi technique will provide answers closer to the true value than any single representative opinion. In general, Delphi techniques have three features: anonymity, controlled feedback and statistical group response. Anonymity reduces the effect of dominant individuals. Controlled feedback reduces noise by providing results of a previous round to the participant. Statistical group response ensures that every member in the group is represented.

used to derive the weights consisted of the Battelle research team of ecologists, engineers, planners, social scientists and landscape architects.

Once value functions and parameter weights were established, multiplication for each parameter resulted in specific quantitative estimates of environmental impact termed environmental impact units, or EIU. Summation yielded the total environmental impact of the project. The impact "with" and "without" the project could now be compared, as well as in different locations within a large project. Elements of the environment that were significantly changed in an adverse direction were identified by "red flags", based on arbitrary levels of magnitude of change. Multiplication of the value functions and parameter weights is comparable to the multiplication of the magnitude and importance values of the Leopold matrix. Thus these two types of preparing environmental impact statements are quite similar in basic format, although the Battelle model is much more comprehensive, detailed and complex in scope.

There is one major difference between the two methods, however. The Battelle model includes environmental pollution parameters in its list of environmental impacts, a category whose inclusion is open to criticism because of the possibility of double counting. In their assessment of weights, the team allocated a weight of thirty-one points (out of 1,000) to the parameter of dissolved oxygen (DO) in the environmental pollution category. On the other hand, only fourteen points were given to the parameter

of sportfish in the ecology category. Yet, why are high DO levels desired? According to them (27, p. 44), "Low levels of dissolved oxygen adversely affect fish and other aquatic life. . ." This means that high DO levels are desired to ensure the existence of fish and aquatic life. The demand for high DO is a derived demand from the demand for fish, to ensure water quality sufficient for the survival of water life. It is not the high DO that is actually demanded, it is the fish and other life that is thereby permitted to live which is desired. Hence, including such parameters as DO, BOD, coliforms, Ph, temperature, turbidity in relation to water, and other parameters such as hydrocarbons and sulfur oxides in air, soil erosion in land, implies that Battelle is viewing some aspects of environmental quality from the supply side, not from the demand side as should be the case in modern economics.

These parameters represent activities and their effects which in the Leopold matrix would be located in the top part of the matrix reserved for actions which detrimentally affect those environmental categories (listed on the side) demanded by society. If "clean" water per se were demanded, the procedure of Battelle could be accepted but such is not the case. It is that which clean water of suitable temperature provides which is demanded. For example, Dee et al. state (27, p. 52), "Water temperature is important primarily because of the sensitivity of fish and aquatic life to temperature changes." This statement implies that fish are desired, not water temperature of a certain level. In summary, the

desire for environmental quality is for what it allows to occur, such as maintenance of natural life and scenic views. "Uncontaminated" water is desired because it is an input to the preservation of natural life. It is therefore a resource necessary for production of a desired good or commodity. Hence, parameters such as DO, BOD, pesticides, and others, should be viewed as intermediary processes and effects resulting from development activities upon desired categories of the natural environment, rather than as the final demand outputs.

A common weakness of the Battelle model shared with the Leopold matrix is that it fails to provide an absolute measure of environmental quality which can be compared to the net dollar benefits from project construction. Although trade-offs are isolated, and such is valuable, the Battelle model hides and obscures much information in the final aggregate index. A reviewer will likely place little emphasis on the final number. Instead he will scrutinize the components of that number, especially if there are no "red flags", in order to elicit information to be used in comparing tradeoffs. The Battelle EES appears then to be too complex. Too many parameters are involved, some of which are irrelevant as argued in the previous paragraph. As with the Leopold matrix, the public is not involved in the determination of weights. The public is important since they are the ones who will receive the benefits, positive and negative, of the proposed projects.

Highly detailed results are obtained from some very gross inputs in terms of the value functions. Weights are constant over the full range of environmental quality values. In reality, weights as expressed by the public may change after certain threshold levels are reached. Dee et al. also state that the weights should remain constant, once established, for alternative geographic locations. This again, in reality, may not be true. Tastes are almost certain to change over space and time. Hence, appropriate weights at one location should be adjusted to reflect changes in demand at other locations. A logical argument for assuming constant weights is when such weights are established by the public in the region of application, which could be national in scope. This is not emphasized by the Battelle research group.

In reviewing these two major models for preparing environmental impact statements and aggregating across diverse resource and output categories, it appears to be impossible to obtain a 100 percent objective method of environmental impact statement preparation. Certain biases are bound to enter, even in the form of unmentioned impacts. Therefore, the public needs to be involved in all stages of environmental impact assessments. The public is required to establish goals, limitations, weights, acceptable and unacceptable practices, and most importantly, to aid in the allocation of resources between conflicting objectives by comparing trade-offs. This implies emphasis on institutional structures to aid in the establishment of public participation and thereby ensure the



accepted goal of democracy. Public demands need also to be continually monitored so that changes in demand can be incorporated over time.<sup>1</sup>

### Model Development

The previous chapters and the prior portion of this chapter have provided the background which was used to develop the model employed in this study. The purpose of the model is to incorporate environmental quality objectives into project evaluation techniques. The general procedure for development of the model used in this study is now summarized in the form of seven steps:

#### Step 1 - Problem delimitation

The basic purpose of this step is to isolate a specific case where it appears there are significant externalities flowing from investment in natural resource development. Such appears likely in the construction of the proposed Ames reservoir on the Skunk River in central Iowa, and subsequent inundation of certain categories of the natural environment. These amenity values have not been considered in the benefit-cost calculations of project

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<sup>1</sup>The United States Water Resources Council in its 1970 and 1971 reports by the special Task Force (89, 90) suggest that environmental quality impacts be incorporated by listing the physical impacts of development upon environmental categories. A side display of information is then prepared to supplement benefit-cost analysis. It was not considered a model as comprehensive in scope as those just discussed above.

feasibility.

The general objective is to maximize social welfare in a multiple-objective framework. The problem is to identify the trade-offs involved between the social objectives of economic development and environmental quality, to determine the significance of these trade-offs, and to isolate possible combinations which will maximize social welfare. Maximum welfare is impossible to achieve without a social welfare function. However, the GNP criterion is generally accepted as a proxy for social welfare. Knowledge of the monetary value of amenities aids in identifying combinations of output that will add most to GNP.

#### Step 2 - Economic development

To obtain a trade-off curve it is necessary to identify the measure to be employed on the economic development axis. As was discussed previously in this chapter the net benefits from benefit-cost analysis serve as an appropriate measure for the economic development axis.

#### Step 3 - Environmental quality--magnitude

This step is similar to the determination of magnitude in the Leopold matrix and the estimation of value functions for parameters in the Battelle EES. It is first necessary to define precisely the region in which physical environmental impacts are expected to occur from project construction and operation. Then a complete inventory is taken of those resource categories which

will be affected and which appear to be valued by the public in general. Determination of magnitude involves the research of many diverse disciplines. A magnitude function for each category can be obtained by altering the scale and mix of activities, and the effect of other alternatives to the basic project under consideration.

#### Step 4 - Environmental quality (importance)

As in Step 3 this step is similar in meaning to the determination of importance in the Leopold matrix and the estimation of parameter weights in the Battelle EES. This step ranks the relative importance of the environmental categories identified and physically measured in Step 3. There are several means of determining the group responsible for evaluating the importance of each category. The Leopold matrix relied upon the planner for importance evaluation while Battelle employed a Delphi board composed of experts. It was felt in this study that the public itself should be consulted in determining relative importance. The public should become involved because it receives most of the positive and negative impacts of a project. By directly involving the public less chance is likely to make errors in determining the relative importance of the environmental categories.

Such a survey of public opinion is analogous to the measurement of demand for any particular good. Hence, it is useful to determine those characteristics of the public which significantly

(from a statistical sense) affect responses. This allows the possibility of gauging shifts in demand as population variables change over time. Many population variables could be related to responses. Included could be age, sex, occupation, education, income, size of family, rural-urban, and length of residency variables which may affect responses, and subsequent ranking of categories.

At the same time it is useful to determine reasons why members of the public react as they do. This is useful, not only as a check on their responses, but because it provides information for planning purposes by determining needs that are common to the public, or needs which may have been unrecognized previously.

A physical scale to be used in ranking categories needs to be developed. Several possibilities exist. The Leopold matrix used a scale of 1-10, with 10 being the most important. The Battelle EES allocated a 1,000 points between the parameters, with the most important receiving the most points. This latter method appears to have considerable merit since it is equivalent to allocating a fixed budget between competing demands to maximize personal satisfaction or utility.

Another technique is the Certainty Method, developed in the science of sociology (91). The Certainty Method is useful for the quantification and measurement of individual opinions. The public respondent is asked to make two decisions regarding the stimulus of a particular statement: 1. a directional judgment such as agree or

disagree, and 2. a certainty judgment about the directional decision (from not very certain to very certain). For example, members of the public are asked to agree or disagree to a statement such as "Preservation of forest x is important to you", and then asked to record the intensity of their negative or positive response according to a scale of 1-5 where 1 is not very important and 5 is very important. Used in this way the method yields a numerical score of 11 points (including one point for indifference) which ranks all environmental categories from very unimportant to very important.

The Certainty Method is useful since it provides a definite means of ranking. It appears superior to the point-allocation scheme in terms of presentation of Step 3 inventory results to the public for ranking, mainly because of its simplicity and ease in incorporating into questionnaire format. Mental demands upon the public respondent are kept more to a minimum, which seems to be less true of the point-allocation system, where the respondent must continually add up points to ensure the budget is being fully spent. If, however, the number of categories is few, then a point-allocation scheme can also be used to provide a check plus more detailed information in regards to preferences.

After public rankings have been obtained, with the Certainty Method, and the statistical mean obtained which provides a measure of overall response as to the importance of each category, simple multiplication of magnitude times importance will provide a

measure of environmental impact of the project upon each category identified. Summation over all categories will yield an aggregate index value of the overall impact of the project under consideration. The level of this aggregate index will vary as the project is altered in mix and scale, or as alternatives are explored.

#### Step 5 - The trade-off curve

A trade-off curve can now be derived using the final results of Step 4 for the environmental quality axis and the results of Step 2 for the development axis. A curve is traced out when developments are altered in scale and activity mixes. For consistency in comparison the number of environmental categories should remain fixed between alternative project proposals.

#### Step 6 - Monetary measurement of amenities

It was discussed previously that knowledge of the trade-off curve does not automatically choose the optimum combination on the curve for maximum social welfare. To apply the criterion of maximum GNP a measure of the monetary value of amenities is required. An estimate of such a measure can be made by applying the interview method of willingness-to-pay models, as employed in outdoor recreation. A method of adapting interview techniques to obtain monetary estimates of amenity services is as follows.

Natural resources such as vegetation and wildlife that would be flooded by the Ames reservoir could be preserved by placing all or most of the natural area into a park system with the free-flowing

river as the center of attraction. Then, it is possible to determine the total benefits flowing from such a park since it provides a facility for outdoor recreation. The interview method of estimating benefits provides a useful tool for evaluating benefits in the case of such a future facility. It can also be utilized to include those members of the public who appreciate the resources even though they do not actively enjoy them by participating in outdoor recreation. Such people can be asked the amount of money they would be willing to spend to aid in the establishment of the park system.

Chapter III presented certain arguments about the relevancy of consumer surplus measurement. It was also noted, however, that the value attributable to a site can be obtained by summing the total expenses incurred to visit the site. This is directly comparable to the total revenue for conventionally priced market goods because consumers must allocate their budget between recreation and other goods and services. The problem of consumer surplus can therefore be bypassed if it is assumed that the total amount of money that people are willing to spend to visit the site and/or aid in its establishment is fully spent on these purposes. To achieve this, it is assumed that it is possible to tax all of the money pledged over and above the amount required for travel and other directly related recreational expenses and to use these tax returns to aid in site establishment. In this way the total willingness to pay as expressed by the interviewed person can be

collected. Such an assumption seems reasonable if the person is asked directly to state the maximum amount of money that he/she is willing to sacrifice. It is not measurement of consumer surplus since nobody is receiving any surplus. However, it is comparable to the revenue which a discriminating monopolist could collect.

This method thereby makes it possible to attribute monetary values to the environmental categories under consideration. Its use determines an estimate of the monetary magnitude of the environmental quality index.

#### Step 7 - Pareto-betterment

Step 5 estimated a trade-off curve. It was argued earlier in this chapter that obtaining more of one good while holding the level of the other good at a constant level would be desirable for society. Such a redistribution of social outputs was termed a Pareto-better redistribution. No knowledge of prices is required. Step 7 hypothesizes that removal of institutional rigidities will result in the establishment of a Pareto-better allocation of output from natural resources. Complete removal of all rigidities will result in the identification of the production-possibility frontier for the two goods in question, namely, environmental quality in the region of consideration and net monetary benefits from resource development.

Once the frontier has been obtained a particular combination of outputs must be selected. Opportunity cost can be employed but is indecisive. Step 6 aids in making the choice by estimating



monetary benefits that flow from environmental quality. The combination yielding highest monetary returns is likely to provide the optimum combination of outputs under the maximum GNP criterion. Even if the frontier is not known, or reached, knowledge of environmental quality monetary benefits will aid in choosing between two incompatible uses of the same natural resources since directions are provided to allocate resources which will maximize the societal gross national product.

## CHAPTER V. PHYSICAL IMPACT, SURVEY DESIGN, AND QUESTIONNAIRE DEVELOPMENT

This chapter describes the achievement of Step 3 in the model developed in the previous chapter, and lays a foundation for achievement of the remaining steps 4 to 7. Step 1 was previously accomplished in Chapter I, while Step 2 was described earlier in Chapter IV.

The first section of this chapter describes the magnitude of physical impact that the Ames Reservoir project, as proposed by the Corps of Engineers, will have upon seven chosen natural resource categories in the region to be flooded. Included is a discussion of the magnitude of impact generated by a smaller reservoir which would serve recreational purposes only. This smaller project represents an alternative proposal to the Corps plan. The second section describes elements involved in the design of a survey used in this study. The survey was used to obtain information which provides relative weights (demands) for the selected resource categories plus additional information regarding the absolute value of amenity benefits flowing from the resources. The third section describes development of the questionnaire used in the survey to obtain the required data.

Magnitude of Physical Impact  
in the Study Region

General physical description of  
the Upper Skunk River basin

The Ames Reservoir is proposed to be located on the upper Skunk River, near Ames, Iowa. The general location of the Skunk River and the Skunk River basin is shown in Figure 5-1 (as adapted from 44a, p. vi). The upper Skunk River basin, north of Colfax, is characterized by flat upland prairie which has been almost entirely placed into the production of agricultural crops.

In the reach of the Skunk River between Ames and Story City, the site of the proposed reservoir, the Skunk River valley provides a visual and physical change from the relatively level landscape of the upper basin area. Native forest is found in the valley slopes, as well as on the flood plain. The valleys of the Skunk River and its major tributaries (Keigley's Creek, Long Dick Creek, and Bear Creek) are narrow in this region in comparison to the Skunk River valley south of Ames.

The narrow meandering river channel north of Ames is still in a relatively natural state. In comparison, the river downstream and south of Ames has been channelized (4, p. 1-4-4). Channelization of the stream has changed stream characteristics markedly, resulting in a broad, straight channel which, located in a wide, cropped floodplain, provides a direct contrast to the stream reach north of Ames.

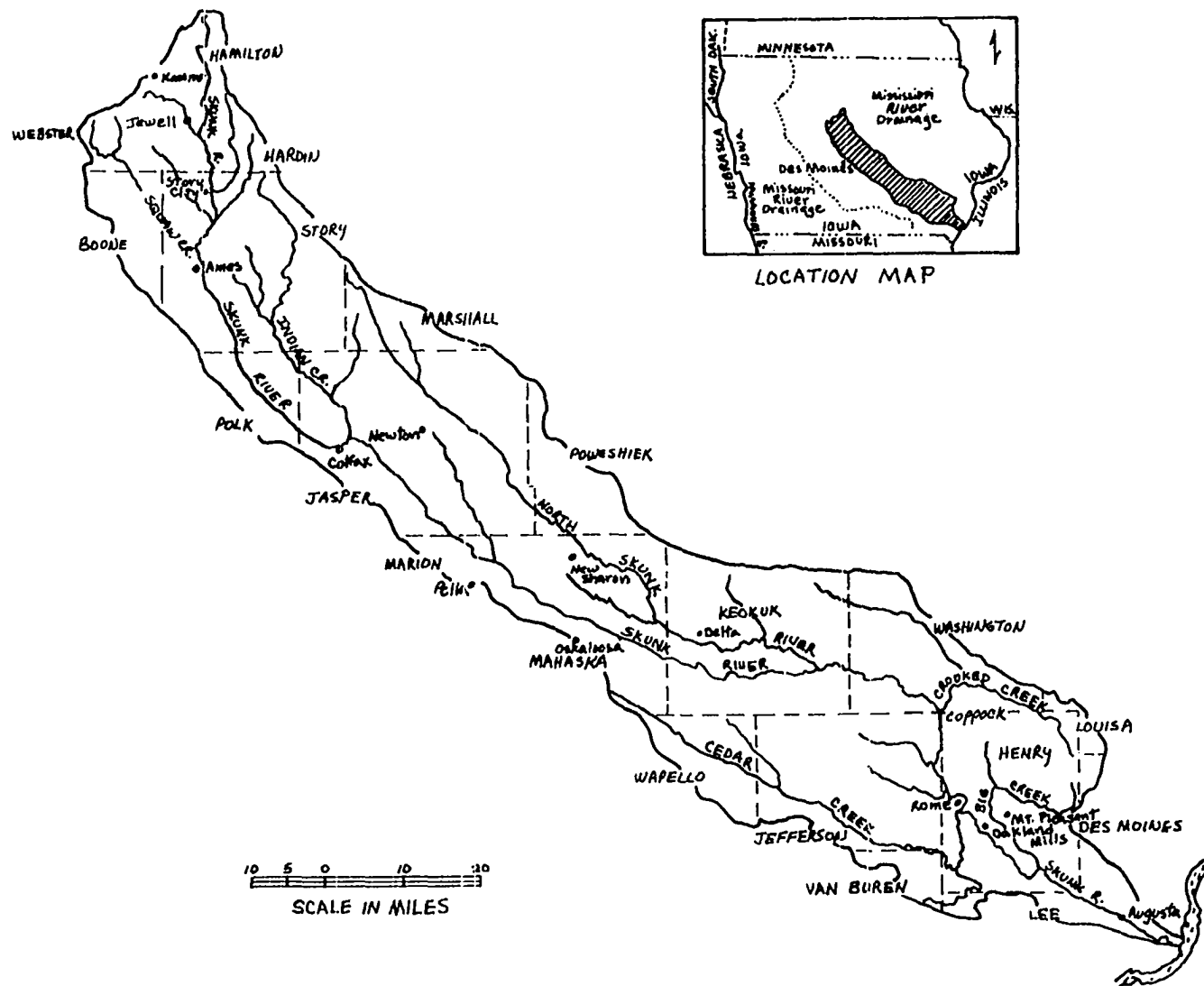


Figure 5-1. The Skunk River Basin

### Reservoir development proposals

The location of the proposed multiple-purpose Ames Reservoir and the land area to be inundated is shown in Figure 5-2.<sup>1</sup> The reach of the river to be flooded is frequently considered to include the most scenic portion of the upper Skunk River valley. The scenic attractiveness of the valley and the natural resources located in this area provide the flow of amenity services referred to in previous chapters and the subject of measurement in this chapter.

The conservation and flood control pools of the project, as proposed by the Corps of Engineers in 1968, are represented in Figure 5-2. The 1968 revision of the project added two subimpoundments to the 1964 proposal (81, 84). About 2100 acres would be flooded in the conservation pool, 2900 acres in the flood pool, and 185 acres in the two small subimpoundments at the dam-site and along Bear Creek.<sup>2</sup>

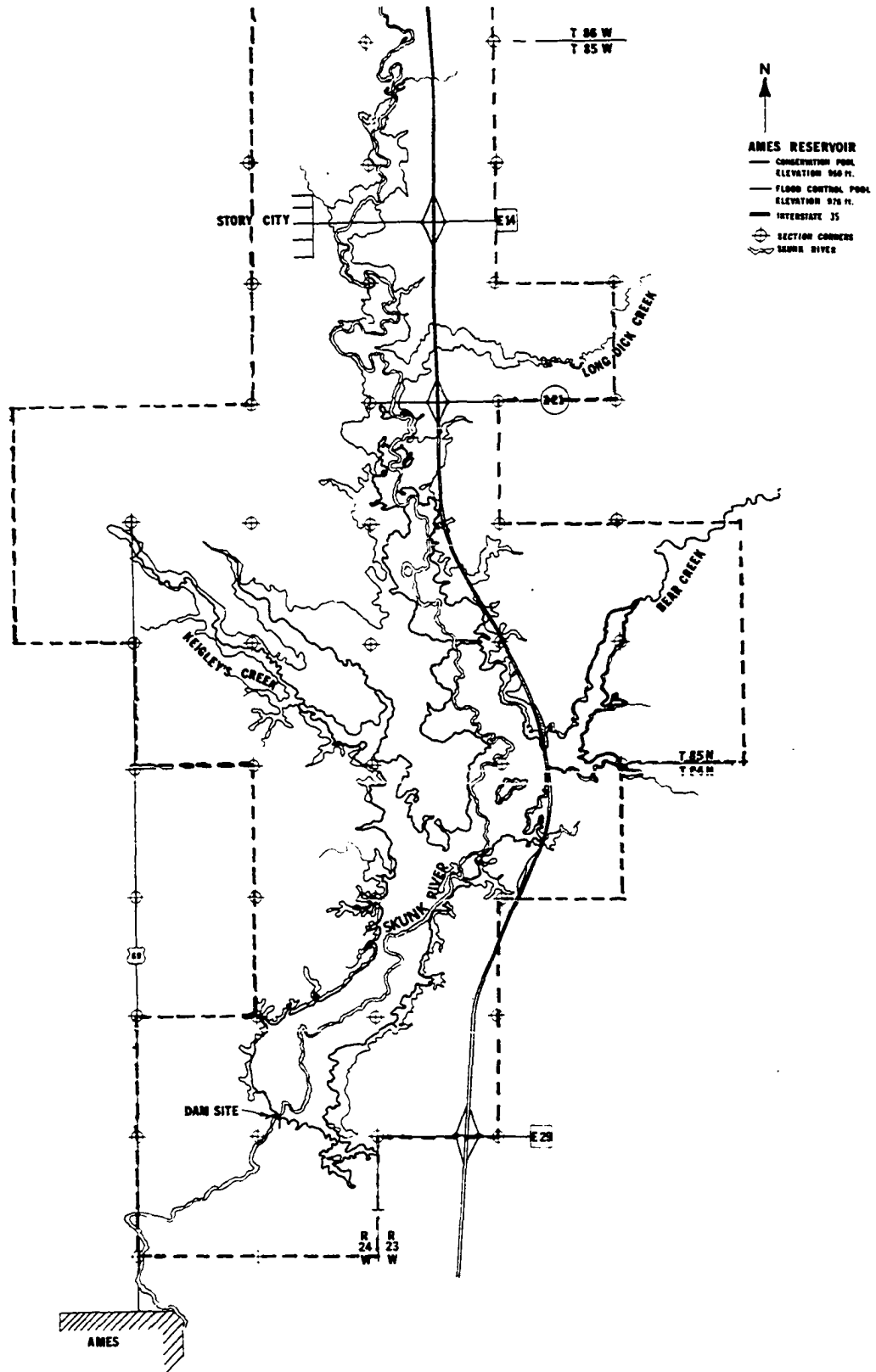
An alternative reservoir proposal considered in this study is a 1400 acre recreational lake. This smaller lake is of interest

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<sup>1</sup>The map in Figure 5-2 was obtained from Dr. Roger Landers, Department of Botany and Plant Pathology, Iowa State University, Ames, Iowa, a project co-leader of the Ames Reservoir Environmental Study.

<sup>2</sup>These acreages were estimated by the Ames Reservoir Environmental Study, 1972-73, and made available, in draft chapters of the report, by Dr. Merwin Dougal, Department of Civil Engineering, Iowa State University, Ames, Iowa.

Figure 5-2. The Skunk River and the Ames Reservoir project, as proposed by the Corps of Engineers



because it would flood fewer natural resources and illustrates institutional rigidities since the Corps of Engineers are primarily responsible for flood control. The Corps did not consider the feasibility of a single-purpose reservoir for recreational purposes only. The recreational lake would have a dam-site at the same place as the multiple-purpose project and would occupy about two-thirds of the conservation pool delineated in Figure 5-2. Pool elevation of the recreational lake would be at 940 feet above sea level as compared to 950 feet for the conservation pool of the multiple-purpose project (16).

#### Magnitude of physical impact

Data on the magnitude of physical impact of the two reservoir proposals, the multiple-purpose reservoir and the single-purpose recreation reservoir, upon vegetation, wildlife, and stream characteristics were available from an inter-disciplinary, inter-university environmental study of the regions to be flooded. The study, initiated in early 1972, was a joint effort by researchers at Iowa State University, Ames, and the University of Iowa, Iowa City, to determine the environmental impact of the Corps of Engineers proposed project. The study would aid the Corps in the preparation of an environmental impact statement to accompany requests for Federal project funding, as required by the 1969 National Environmental Protection Act, discussed in Chapter I and Appendix E.

The Ames Reservoir Environmental Study (ARES) designated a



study area of 34 square miles (about 22,000 acres) for "environmental resource evaluation". Each square mile would contain some portion of the multiple-purpose project. The study area of ARES is outlined by the dotted lines in Figure 5-2. Much information was generated by ARES in regards to the living and non-living resources of the study area.

ARES also provided an indication to this present study of the natural resources in the region likely to provide amenity services to the public at large. The two natural resources of wildlife and forest were felt to constitute considerable amenity value. A third category, the Skunk River itself, was selected because of its unique setting and natural characteristics, likely to provide amenity services of positive value.<sup>1</sup> Fourth and fifth categories of resources providing amenity services were recognized, constituting remnants of native prairie (prairie relics) and pot-holes. These provide scientific and historical values, as well as diversity. Since considerable acreage of wooded pasture, in addition to the above mentioned forest, would be flooded, wooded pasture was considered for a sixth category. Wooded pastures are frequently quite attractive and provide some wildlife habitat. Since the multiple-purpose project would also affect certain of the county and local parks in the region, wooded parks were

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<sup>1</sup>The Skunk River north of Ames was given the name "free-flowing stream" in order to differentiate between the channelized portion, south of Ames, and the river in its original stream bed, north of Ames.

included as the seventh and final resource category. The list could be expanded by adding further resources (e.g., archaeological sites) and by creating sub-classes. However, the number of resource categories was restricted since a survey by public interview involving these categories would be undertaken. The seven categories chosen were felt to provide most of the amenity services offered by the Skunk River valley in the region to be flooded.

Appendices A and B contain more information on each of these resource classes. Appendix A provides basic information as presented to the public on the questionnaire, while Appendix B supplements this information with additional detail. Table 5-1 provides a summary of the existing (1972) acres of each category, where relevant, in the 22,000 acre study area of ARES. The table also includes the number of acres expected to be destroyed or damaged by the multiple-purpose and recreational reservoirs. For each project and category an index of magnitude of impact is provided. This index adopts the "Leopold" scale of 1 to 10 where 10 designates the worst possible impact and 1 designated very minimal impact. The index values in Table 5-1 were obtained by calculating the ratio of the number of acres destroyed or damaged to the total acres in the ARES study region and multiplying by 10. Values were rounded to the nearest half. Calculating ratios makes the implicit assumption that resource categories are homogeneous throughout.

The resource categories of prairie relics and forest were

Table 5-1. Magnitude of impact upon natural resources in study region

Natural resource categories	Total acres in ARES study region <sup>a</sup>	No. acres destroyed or damaged by		Index of magnitude of physical impact	
		Multiple-purpose project <sup>a</sup>	Recreational Lake <sup>b</sup>	Multiple-purpose project	Recreational Lake
1. Wooded parks	70	35	0	5	0
2. Prairie relics (total)	70	17	0	2.5	0
Dry prairie	25	7	0	3	0
Wet prairie	45	10	0	2	0
3. Prairie potholes	27	11	5	4	2
4. Forest (total)	2000	1300	510	6.5	2.5
Upland	1100	600	135	5.5	1
Lowland	900	700	375	8	4

5. Wooded pasture	900	475	135	5.5	1.5
6. Wildlife	3750 acres of wildlife habitat <sup>c</sup>	2175 acres of wildlife habitat	775 acres of wildlife habitat	6	2
7. Free-flowing stream	12 river miles of the Skunk River <sup>d</sup>	10 river miles would be replaced or altered <sup>d</sup>	4 river miles would be replaced <sup>d</sup>	8	3.5

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<sup>a</sup>Source: (16, Table 1-3-1, p. 1-3-56).

<sup>b</sup>Source: (16, Table 1-3-3, p. 1-3-60).

<sup>c</sup>Wildlife habitat was assumed to include forest, wooded pasture strings of trees along watercourses, assorted tree plantings, wooded edge, fence rows, virgin prairie, marsh, and potholes, and existing ponds and reservoirs.

<sup>d</sup>From Figure 5-2.

subdivided into two sub-classes each. Values are provided in Table 5-1 for these sub-classes in addition to the total. The sub-classes were felt necessary because they represented significant types of prairie relics and forest. In addition, lowland forest is affected relatively more severely than the upland forest by the recreational lake. Total acreage values for these classes of prairie relics and forest, however, were used in the interview survey (discussed later in this chapter) in an effort to reduce the complexity of the interviews and because differences between resources classes was still greater than within resource classes.

Table 5-1 indicates that the multiple-purpose Ames reservoir, as proposed by the Corps of Engineers, will have the greatest impact upon lowland forest and the Skunk River itself, destroying or altering about 80 percent of these categories. Lesser impacts are noted upon wooded parks, upland forest, wooded pasture, and wildlife, ranging from 50 to 60 percent destruction and alteration. Total forest is affected by a magnitude of 65 percent. Prairie relics and potholes are least affected.

As indicated in Table 5-1, the recreation lake appears to exert a lesser physical impact upon resources in the ARES study area. Existing wooded parks and prairie relics are unaffected. Again, the most affected categories are those of lowland forest (40 percent magnitude of impact) and the Skunk River (35 percent magnitude of impact). Only 10 percent of upland forest is affected, a considerable reduction from the effect of the multiple-

purpose reservoir.

A listing of physical impact, as in Table 5-1, remains unsatisfactory because no indication is provided of the relative importance of each of the resource categories in providing amenity services, nor of the absolute importance of the resource categories when compared to the monetary benefits of both the multiple-purpose and recreational reservoirs. The following sections describe preparation of a survey designed to obtain this information, in an attempt to better evaluate the feasibility of these two projects versus the alternatives of doing nothing in the region and a green-belt park system.

#### Elements of Survey Design

As stated in Step 4 of the model development section in Chapter IV, it was felt that the public should be consulted for ranking the categories chosen in the previous section. In addition, public willingness to pay to visit a green-belt park system was needed, if such an area were established to preserve the resources providing amenity services. This section describes the procedure employed in designing elements of a public survey that would obtain the desired information.

In order to obtain a representative public viewpoint it was believed that the technique of personal interviews would serve best. Mail questionnaires have the disadvantage of requiring literacy in reading and writing, in addition to generally low and frequent improperly prepared returns. Although survey expenses

are increased with personal interviews, the percentage rate of completed questionnaires is higher. Hence, if a random sample is chosen, it is more likely that the distribution of population characteristics will remain similar in the returns as in the original sample.

It was first necessary to decide who to sample in the sample area (discussed below). Since a fairly large geographical area was involved it was felt that only one person per chosen household should be interviewed. The head or the spouse of a household were subsequently selected as respondent. Since housewives generally are more likely to be found at home, a disproportionate number of housewives were expected to be interviewed. To ensure that male heads of households would also fall into the sample, the male would be interviewed in about half the cases and the female in the other half. If a household was found to have only a head, and no spouse, the head was to be interviewed. No persons seventeen years or age or younger would be interviewed. Since a question would be involved which concerned spending of the household budget, it was believed that the head or the spouse would best represent family spending attitudes and household opinions in other questions on the questionnaire.

The area to be sampled and sample size were the next two problems to be considered. In Appendix 5 of the previously mentioned Ames Reservoir Environmental Study, an area of influence of the multiple-purpose Ames Reservoir was considered to be a

surrounding 9 county region in central Iowa.<sup>1</sup> These 9 counties represented a 50 mile radius of influence for urban and county planning purposes, including the effective reservoir recreation area (69, p. 5-1-2). The same region was also chosen for the area to be samples in the present study. The region was deemed satisfactory because it was large enough to include members of the public who were not likely to be directly influenced by the project. It included the metropolitan area of Des Moines to test large city attitudes. Additionally, the area was large enough so that the effect of distance could be employed as an independent variable in explaining responses. The area was not too large to significantly affect survey expenses.

In 1970, total population in the 9 county area was about 567 thousand, which represented about one-fifth of the State of Iowa total (69, p. 5-1-60). Hence, the sample area would contain a significant proportion of Iowa's population. However, one county, Polk County, which includes the City of Des Moines, contained about 286 thousand people. Hence a proportional random sample of the area population would result in about 50 percent of the responses from one county. No problem would result if enough responses could be obtained from the remaining counties to achieve a representative sample. However, since survey budget

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<sup>1</sup>The 9 counties included a four county primary area of Boone, Hamilton, Hardin and Story Counties, plus a five county secondary area of Dallas, Jasper, Marshall, Polk and Webster Counties.



restrictions existed and since Des Moines was felt to remain well represented by a lower percentage, the sample area was divided into an inner and outer stratum with interviews to be divided about equally between the two strata. The inner stratum consisted of Story County, which would contain the Ames Reservoir, plus some adjoining townships of neighboring counties. Generally, the inner stratum included the population living within approximately 15 miles of Ames. The outer stratum contained the remainder in the 9 county region. In the final analysis, about 24 percent of the completed responses were obtained from Polk County.

Appendix C contains a detailed account of the method employed in drawing the sample by the Statistical Laboratory at Iowa State University. Various persons connected with this laboratory were involved in a team effort for details in planning the survey, drawing the sample, preparing the questionnaire, conducting the interviews, collecting and coding questionnaire information, and aiding in obtaining and analyzing results. Initial planning, restricted by a survey budget, aimed at achieving 300 completed personal interviews; 294 were achieved in actuality.

#### Questionnaire Development

The questionnaire used in obtaining personal interviews represents the focal point of a survey in that it is the vehicle for obtaining and storing the information desired from respondents chosen in the random sample. Development of the questionnaire became an important and difficult portion of the study. The basic

problem involved the presentation to the public of general information about the multiple-purpose and recreational projects and project effects upon the seven selected natural resource categories. Generally, surveys are designed to obtain information from chosen respondents regarding the store of knowledge and opinions held by the respondents. This survey was somewhat unique in that information was first presented to the respondent to expand his knowledge before he was requested to respond to any questions.

Presenting information about the two reservoirs and their physical impacts served the purpose of providing a common base of information to all respondents. Thus, for example, those who had just moved into the region and those who may never have heard of the proposed Ames Reservoir were now basically informed of its physical impacts upon selected natural resources. This information, obtained by specialists at universities, might also serve to dispel and nullify possibly less accurate information that respondents may have obtained from other sources. The information about the selected resource categories, as obtained by ARES, represented the latest and most comprehensive available.

Information was not presented about the benefits and costs of the projects from benefit-cost analysis. Much controversy exists over the calculation of these values, especially benefit estimation. Failure to present benefit-cost information subsequently posed the hazard of not allowing a "fair" comparison of

net monetary benefits with the environmental costs. However, the economic (and political) feasibility of both projects was felt to be implied by continual reference to the projects on the questionnaire. Respondents could weigh the potential benefits of the projects to themselves versus the sacrifice in natural resources required to achieve the benefits. If the projects were shown unfeasible by some method previously, no need is even required to show concern about their impact upon the environment and hence no survey as this would be required to expand evaluation procedures.

Problems were encountered in deciding the level of detail of information to present about each resource category. This was resolved in many consultations with Hazel Cook of the Iowa State Statistical Laboratory whose responsibilities included direct supervision of the interviewers involved. Her experience as an interviewer in past surveys and in preparing questionnaires for other projects provided valuable guides in deciding which information was "digestible" by the public during the process of the personal interview. Compromises were required, generally in the direction of less detail. Continual fear was expressed that the respondent would "lose attention". In an attempt to maintain continued interest and concentration, visual aids such as charts and tables were provided to the respondent. The questionnaire also followed a regular pattern so as to avoid too long a period without some involvement of the respondent.

Further description of the questionnaire development phase is now best presented by referring specifically to each section of the four section questionnaire. The questionnaire is reprinted in Appendix A.

### Section I

Household information was desired as various household characteristics were hypothesized to influence responses. These included age, education, and occupation of the head. Other variables such as the number of years the head has lived at the present address and years residency in Iowa of the head were felt as possibly influencing responses. Additionally, it was believed that the responses may be influenced by the nature of residency of the respondent. As a result the respondent was asked whether one-half of his (her) life had been spent on a farm, in a rural non-farm area, in a city under 10,000 population, in a city over 10,000 population, or in none of these.

Desired additional household information concerned the household's income, and ages and numbers of other household members. Distance from the household to the Ames Reservoir was also required but could be obtained from maps available to the Statistical Laboratory, hence not asked on the questionnaire.

As can be noted in Appendix A, the income question was placed near the end of the questionnaire. In this location it was less likely to affect responses in case the respondent would be offended by questions concerning family income, or if the respondent would

lose "rapport" with the interviewer by refusing to answer. Likewise, the nature of residency was placed at the very end of the questionnaire as it provided a good conclusion to the interview.

## Section II

This second section, the longest section in the questionnaire, employed the Certainty Method for quantification of opinions about absolute and relative importance of preservation of the seven resource categories. The Certainty Method was introduced and described in Step 4 of the model development section of Chapter IV. The method was chosen for application in this study because of its simplicity and ease of application. It allows eleven alternative possible values for opinions about statements--from strongly disagree to strongly agree. The Certainty Method is also amenable for statistical techniques such as calculating means and regression. The level of means over all respondents would provide an absolute level of amenity values as well as indicating the relative contribution of each resource category.

Use of the Certainty Method is as follows. For each of the seven resource categories, in the same order as presented in Table 5-1 with "Wooded Parks" first, a description of the natural resource in question was provided to the respondent. A brief discussion of the physical impact that the multiple-purpose project would make upon the resource was next presented. The respondent was then requested to agree or disagree with a statement concerning the importance of preservation of the natural resource in

question to the household and family. Preservation would maintain desired amenity values. If he (she) agreed or disagreed with the statement the word "agree" or "disagree" was circled. The respondent was then requested to state how strongly he or she agreed or disagreed with the statement in question. On a 5 point continuum the number 1 was used for mild strength of agreement or disagreement and the number 5 was used to register very strong agreement or disagreement. If a person was indifferent or could offer no opinion in regards to the statement both agree and disagree were circled. In the laboratory these responses were transferred to an 11 point scale with "disagree 5" represented by 1 and "agree 5" represented by 11. Indifference was given the value 6. Then, for example, moderate strength of agreement, "agree 3", would be transformed to 9 on the 11 point scale continuum.

In the cases where the recreational reservoir would also provide physical impacts upon the natural resources in question, a brief description was made of the extent of impact, followed by a similar statement regarding importance of preservation to the household. Four such cases occurred. Hence, in total, eleven statements were made. A statement regarding the impact of the recreational reservoir upon the free-flowing stream was not included. It was felt by this researcher that the recreational reservoir would still completely transform the nature of the stream and valley between the damsite and Story City. This was not reflected in the index of physical magnitude as developed in

Table 5-1.

An anticipated weakness in the Certainty Method as employed in this study concerned doubts as to whether or not respondents would ever disagree with any of the statements. Several reasons could be cited for expecting biases to occur on the agree side. One is a desire of an unknown number of respondents to please the interviewer by stating that which the interviewer or project leaders might possibly prefer to hear. Since the very presence of the interviewer and questionnaire indicated concern about the resources in question, the interviewer would possibly be best pleased by showing preferences that indicated concern over the environment. A second reason for expecting biases to occur on the agree side is that to indicate indifference or disagreement with the statements shows a tendency to be against nature (and "motherhood"). A third reason hypothesized could be termed "mental laziness" on the part of the respondent. It is much easier to choose one basic answer, such as "agree 3" which will likely offend no-one, and deviate very slightly during the course of the questionnaire, instead of thinking through each statement as it occurs. A related problem is that the interviewer might possibly not allow enough time to provide careful thought, or stating the information too rapidly for mental assimilation to occur.

Despite these possible biases, information would still be obtained to rank the resource categories in a relative ordinal

manner. Even if all respondents agreed for reasons cited above, it was thought highly unlikely that responses would not vary in the agree continuum. A resource that was definitely less or greater valued than others for its amenity services would most likely be reflected in the strength of agreement, assigning it a slightly lower or higher number than some "norm" of the respondent.

Since the number 6 on the 11 point scale represents indifference, subtracting the value 6 from each of the statement means will provide a transformation of the mean back to a five point scale in which 1 represents minimal level of agreement (minimal importance of the category), and 5 represents a maximal level of agreement (and maximum importance of the category). Multiplication by 2 will convert the 0 to 5 scale to a 0 to 10 scale, similar to the scale of physical magnitude developed in Table 5-1. However, because of the possible biases referred to above, it was felt that these levels provided only a reliable indication for the ranking of categories, and less of a reliable scale for the absolute level of importance since the value 10 was chosen arbitrarily.

Nevertheless, the means of responses, when transformed as above, can be used as measures of importance in an analogous manner as the index of importance employed by Leopold et al. in the Leopold Matrix (52). Furthermore, multiplying, for each resource category, the physical index of magnitude from Table 5-1 by the index of relative importance for the same category, and summing over all 7 resource categories, will provide an aggregated index



of environmental quality at the project site for each project. These aggregated index values, when compared to each other, should indicate relative magnitude of each project's effect upon the natural resources of the study area. These index values can be entered as a measure of environmental quality on the environmental quality axis to develop a production-possibility curve for use in the broad productivity criterion.

In order to obtain some information about reasons for agreeing with the statements, several possible reasons were listed after all categories except wooded parks and wooded pastures. These were not considered because it was felt that these categories were relatively minor in importance to the remainder. They could therefore be excluded in an effort to maintain the interview as short as possible. Various reasons were cited after the other categories, usually focusing upon preservation and heritage values (which reflects time preference and is therefore of potential value in determining relevant discount rates) and the value of the resources for providing outdoor recreation and associated amenity services. The Certainty Method was also used to score responses about possible reasons for agreeing with the previous statement(s) relevant to the category under consideration.

One additional weakness of the Certainty Method was hypothesized. This concerned those respondents who cared greatly for the natural resources that would be flooded or damaged, and who would respond "agree-5" to all 11 statements. In such a case

no information is provided to aid in the relative ranking of the different categories. Yet, it was felt that those persons who are truly concerned with preserving the resources did indeed prefer certain categories over the others, such as wildlife preferred over the wooded pasture. Hence, the point-allocation scheme, as employed by Dee et al. of Battelle (27) and discussed in Chapter IV, appeared to be useful to aid in the relative ranking of projects. Section III of the questionnaire involved a point-allocation scheme, and is now discussed.

### Section III

This section constituted only one question. The respondent was requested to allocate 100 points between the 7 natural resource categories, giving the most points to categories preferred greatest. In order to make the scheme easier to understand and apply, the 100 points were equated to 100 dollars on the questionnaire. The problem became that of forced spending of these 100 dollars coming as "manna from heaven" upon the resource categories with no opportunity to spend the money on anything else. The value of 100 was chosen for convenience so that responses would be equivalent to percentages of the total. Additionally, 100 dollars did not seem to be as an unrealistic figure as might have been 1 dollar or 10,000 dollars.

The respondent was now forced to make hard choices about his preferences while considering all resource categories simultaneously,

rather than one at a time as in Section II. Yet, the process of Section II had provided him with information about each of the resource categories. It was felt that Section III could not have been asked by itself without something similar to Section II preceding, especially in a public survey of this nature.

The main purpose of Section III was to further aid in ranking the resource categories, especially in the cases of respondents who agreed strongly with the statements previously. It was also believed that those respondents who had not previously showed much range of response would now exhibit their preferences more dramatically. Finally, even those who were indifferent or disagreed to the statements in Section II were now forced to reveal their preferences for the resources.

Section III also provided a check on the relative ranking of projects as determined by Section II. The use of correlation techniques, between points allocated and statement means, would later provide a statistical measure of the similarity in ordinal rankings.

Sections II and III were designed to aid in determining the nature of the production-possibility curve. These sections were directed at use of the broad productivity criterion. However, as discussed in Chapters II, III, and IV, one criterion was felt to be inadequate in measuring economic performance with respect to environmental quality as a social goal. Hence, Section IV of the questionnaire was designed in an effort to apply the maximum GNP criterion, the second member of the pair of productivity criteria chosen for application in this study.

#### Section IV

To apply the maximum GNP criterion, a monetary estimate was required of the value of amenity services flowing from the seven resource categories. This was done by questioning the respondent about willingness to spend money to visit the resources under consideration and to aid financially in resource preservation by establishment of a green-belt park system.

After a brief description of the potential green-belt area, the respondent was requested first, in question 9(a), to estimate how many visits a year each household member could be expected to provide if it were established. Summing over all interviews would then provide an estimate of the total "willingness-to-visit" the green-belt area.

Again, as in Section II, a bias was expected to occur from respondents stating more visits than the household would ever provide in reality. One source of bias could result from undue optimism on the part of the respondent. A second possible reason could result from a desire to please the interviewer, as discussed previously. A third source of bias could result from public good characteristics of outdoor recreation facilities. Once facilities are established, they are available for everyone whether or not users shared in the costs. Hence, it is to the advantage of the respondent to overstate expected visits to the green-belt area, to show its popularity and thereby aid in ensuring its establishment if the respondent prefers the green-belt over other types of

recreation facilities. The number of visits, nevertheless, provides an indication of the desirability of the green-belt system, especially if a large number of visits are forecast.

For those households who would provide no visits to the green-belt area, question 9(b) was asked which listed several possible reasons for not attending. For example, if many people replied it was "too far", then the possibility of providing closer facilities should be considered.

Question 9(c) was designed to provide an estimate of activities people hoped to participate in at the green-belt area. Not only would this provide an idea of facilities required, it would also indicate the popularity of alternative activities. If most people wished to observe wildlife, for example, additional argument is made for preserving the existing wildlife in the area.

Question 9(d) represented the "willingness-to-pay" question. The respondent was asked to state the most money that the household would be willing to spend per year to visit the green-belt area or to aid in its establishment. Even though persons may never visit the area they might still be interested in its establishment. This was directed at those people who possibly are aged, infirm, live too far away, or otherwise would participate very little in outdoor activity at the site for some personal reason. However, satisfaction would still be obtained for them by aiding in preserving the resource categories and/or providing a recreation facility for the enjoyment of others such as descendants.

As discussed in Chapter III, biases can enter willingness-to-pay questions because of the public good nature of the services provided. Answers can be biased on the high side if the respondent desires the facility and wishes to ensure its establishment, feeling that he (she) will never be required to pay the amount committed. Biases can also exist on the low side if the respondent fears that entrance fees, or taxes, may depend upon responses. Thus, as suggested by the argument of Bohm (9), an additional sentence was entered into question 9(d) stating that there might be state or federal support but additional financial support may still be required to create the green-belt area. Probabilities of financing were not stated. Thus, upward biases were hoped to be reduced because of the fear of high fees or taxes if full local financing would be required. On the other hand, downward biases were hoped to be reduced because if full state or federal support became available a low monetary response would indicate the undesirability of the project.

As stated in Chapters III and IV, the desired monetary amount was the total household expenses incurred to visit the site and/or aid in its establishment. Expenses would include the cost of auto gasoline required to reach the area, expenses over and above those that would otherwise be made if they did not visit the area (such as extra picnic expenses), and any entrance fees that would be required (amount unknown). Several difficulties were envisioned. One was that people simply may not know what their recreational

expenses are or would be. A second is that the question may be misinterpreted, with the respondent believing that the question was asking the maximum user or entrance fee that the respondent would be willing to spend. A third problem was related to the hypothetical nature of the question. No guarantee is provided that the respondents will do as they say if the facility is constructed or donations requested, including local taxation, to aid in facility establishment.

Those respondents who stated that their willingness to spend was zero were asked to consider four reasons which would possibly account for their responses. One reason suggested that users should not have to pay to visit outdoor recreation areas. This reason, if frequently checked, would provide an estimate of the magnitude of misunderstanding of the willingness-to-pay question.

Finally, a summary question, question 11, was inserted, asking the respondent to rank the three possibilities discussed in the interview for development of the river valley; namely the multiple-purpose project, the recreational reservoir, and the green-belt area, in addition to the fourth possibility of leaving the area in its present state of private control. The latter would still preserve the resource categories in the present, but would provide no guarantee for the future because of unplanned development.

The questionnaire was now complete. Summarizing, the last section, Section IV, was designed primarily to apply the maximum GNP criterion, while Sections III and IV were designed to apply

the broad productivity criterion. Section I and two questions in Section IV provided household information.

After public pretesting of the questionnaire, the final form, as reprinted in Appendix A, was prepared. The next chapter presents the empirical results of the survey.



## CHAPTER VI. EMPIRICAL RESULTS

The previous chapter described elements of survey design in addition to describing development of the survey questionnaire. The purpose of this chapter, Chapter VI, is to present the empirical results obtained in the survey in which the questionnaire was used.

The first section of this chapter summarizes characteristics of the sample population. The second and third sections present results of responses to statements and allocation of points. A regression analysis is included in both sections to determine population characteristics that are related to responses. The fourth section provides estimates of total green-belt visitation and willingness-to-pay when extrapolated from the sample to the study area population. Prediction equations are developed with the use of regression techniques. A fifth section presents results of project ranking, and explanatory variables that were identified. The final section summarizes the trade-offs between environmental quality and economic development that were obtained, as well as describing results in applying the GNP criterion to include amenity services obtained from the environment.

## Population Characteristics in the Sample

The survey collected 294 completed questionnaires, with 177 in the inner stratum and 117 in the outer stratum. Table D-1, Appendix D, lists the number and percentage of returns from various

localities in the study area. The city of Ames provided 16 percent of all responses, the city of Boone provided 9 percent, and Des Moines and Urbandale together provided about 28 percent. About 17 percent of total responses came from rural areas. The remainder, about 30 percent, were scattered in various towns and cities as shown in the table.

As stated in the previous chapter, information about the head of the household was preferred. Data on the head was felt to better represent a household characteristics than respondent data. The respondent was head of the household in 58 percent of the responses. The respondent was also of female sex in 63 percent of the households interviewed. Age of head ranged from 19 to 93 years with a mean age equal to 47 years. Table D-2, Appendix D, presents ages of heads as grouped into 7 age categories. Table D-3 summarized information about education of head, in terms of years of schooling. The mean years of schooling was 12.5.

Tables D-4 and D-5, Appendix D, summarize years lived by the head at the present address, and years residency in Iowa. The range of years lived at the present address is 0 to 69 years, with a mean number of 12 years. On the other hand, the range of years lived in Iowa is 0 to 93 years with a considerably higher mean of 41 years.

Size of household ranged from 1 to 9 persons. The largest group consisted of two-member households constituting about

34 percent of the total. Table D-6, Appendix D, presents the number and percentage of household members falling into each size group represented. The average size of household sampled was found to be almost exactly 3 persons. Not shown in the table is that 43.2 percent of the households had additional members between 6 and 17 years of age, and 20.4 percent had members 5 years of age or less.

The occupation of the head and present status of occupation are listed in Tables D-7 and D-8 of Appendix D. Occupations were divided into nine categories. The professional category was largest with 20.1 percent of heads, of which 4.4 percent were students. The next largest category was "craftsman" with 15.6 percent of the total. About 73 percent of all heads were actively working at present, while 16 percent were retired. Seven heads were teachers at the college, an insufficient number to create an independent variable for use in prediction equations.

Gross household income of sample households is listed in Table D-9, Appendix D. Six income categories were listed in the questionnaire. Only 17 respondents refused or gave no response when questioned about household income. These refusals and no responses subsequently generated a problem of "missing data". This was resolved by referring to other information about the household such as education, occupation, address, and age of members in order to estimate into which income group the household would most likely fall. As a result, Table D-9 contains

columns entitled "original data" and "adjusted for non-response". Table D-9 also contains a column which lists the assumed class means for each income category subsequently used in regression.

Table D-10, Appendix D, lists distances by road from each household to "Soper's Mill", assumed to be the middle point of the green-belt area if and when established. This is about 6 miles north and east of Ames. "Soper's Mill" represents the past location of a mill dam on the Skunk River and associated buildings. The maximum distance encountered in the survey was 60 miles. Mileage was calculated from maps available to the Iowa State Statistical Laboratory.

Table D-11, Appendix D, provides results from the final question on the questionnaire, in which respondents stated which residential category they had spent the majority of their life. Of the responses, about 45 percent stated that they had spent half or more of their life in a city greater than 10,000 population. About 28 percent had spent the majority of their life on a farm. The remainder of the respondents had spent the majority of their lives in categories of smaller cities, rural non-farm, and "none of the above".

#### Survey Results--Importance and Ranking of Resource Categories

This section discusses the importance of the seven chosen resource categories in supplying amenity services and the relative contribution of each, as obtained by analysis of Sections II and III

of the survey questionnaire. Household characteristics described in the previous chapter are then employed in regression analysis to determine which characteristics appear to affect responses.

To aid in interpreting following tables and discussion based upon the Certainty Method, the verbal statements which accompanied the questionnaire on a flash card to aid the respondent were:

	very slightly		moderately		very strongly	
Agree	1	2	3	4	5	
Disagree						

In the laboratory, for purposes of statistical analysis, the responses were converted to the following numerical values:

Responses	D5	D4	D3	D2	D1	A/D	A1	A2	A3	A4	A5
Numerical values	1	2	3	4	5	6	7	8	9	10	11

(Where D = Disagree, A = Agree and A/D = Indifference or no opinion.) Thus, the highest mean possible is 11, which signifies that all respondents agreed very strongly to the statement in question.

#### Multiple-purpose project

Table 6-1 summarizes results of applying the Certainty Method to the 11 statements in Section II of the questionnaire. Referring only to the statements concerned with the multiple-purpose reservoir, the resource category of wildlife is shown to provide the highest mean value of all resource categories. The mean value

Table 6-1. Summary of statement responses

Statement number	Resource category	Project <sup>a</sup>	Mean	Standard deviation	% agree
1	Wooded parks	MP	8.2	3.2	73.8
2	Prairie relics	MP	8.1	3.2	72.8
3	Prairie potholes	MP	7.6	3.3	68.8
4	Prairie potholes	Rec	7.3	3.4	63.4
5	Forest	MP	9.7	2.3	91.2
6	Forest	Rec	9.0	2.9	83.7
7	Wooded pasture	MP	9.0	2.7	84.6
8	Wooded pasture	Rec	8.4	3.0	78.4
9	Wildlife	MP	9.9	2.3	92.5
10	Wildlife	Rec	9.5	2.5	89.1
11	Free-flowing stream	MP	8.8	3.0	82.0

<sup>a</sup>MP refers to multiple-purpose project; Rec refers to recreational lake.

% agree-5	% agree-4	% agree-3	% agree-1,2	% disagree-3,4,5	% disagree
35.0	10.2	19.7	8.8	15.0	23.5
32.0	11.2	22.4	7.1	16.3	25.2
23.6	12.3	21.9	11.0	19.9	29.5
25.7	7.9	19.2	10.7	25.0	35.6
57.5	12.2	16.7	4.8	5.1	8.5
48.6	7.8	18.7	8.5	10.5	16.0
43.7	11.3	19.8	9.9	8.9	14.3
36.0	10.6	19.5	12.3	13.0	19.5
69.7	9.5	8.2	5.1	5.8	7.1
59.5	9.9	12.9	6.8	7.1	10.5
45.9	10.2	18.4	7.4	12.9	17.3

of 9.9 for wildlife shows that the average strength of agreement with the statement "Preservation of the wildlife is important to me and my family" was agree-4, which indicates strong agreement among the sample respondents. Seventy percent of all respondents agreed very strongly, agree-5, with the statement.

The second most popular category was forest, in which the mean value was 9.7. In reference to forest, 57.5 percent of respondents agreed very strongly with the statement that preservation of the forest is important.

The third most popular category was wooded pasture, with a mean value of 9.0. The percentage of respondents who agreed-5 was equal to 44 percent. Closely following, with a mean value of 8.8 was the free-flowing stream, the Skunk River itself. About 46 percent of the respondents agreed very strongly that preservation of the stream was important to them.

Wooded parks and prairie relics followed, but with considerably lower means of 8.2 and 8.1 respectively. Thus, strength of agreement was only "slightly important", on the average, to the statement that preservation was important for these resource categories. With wooded parks, 35 percent agreed very strongly, while 32 percent agreed very strongly with reference to the prairie relics.

Preservation of prairie pothole acreage was felt least important as the mean value was 7.6, with only about 24 percent agreeing very strongly that preservation of the potholes was important. This contrasts with the 70 percent very strong agreement



in the case of wildlife.

Fears that respondents would never disagree with the statements in Section II were dispelled, as can be noted in Table 6-1. Almost 30 percent disagreed with Statement 4 concerning prairie pot-holes and the recreational lake. About 7 percent disagreed with Statement 9, referring to importance of preservation of wildlife.

The percentage of agree-5 values was continually noted above because these values showed the greatest range of variation. Very strong agreement to a statement also seems to indicate that the respondent has made a definite decision about the resource in question and is very certain about the direction of his feelings.

The standard deviation followed an inverse pattern to the level of means, with wildlife and forest categories exhibiting the lowest standard deviation (2.3) and potholes the highest (3.3). This shows the higher variability of responses in the lower ranked categories. The lower standard deviations for wildlife and forest indicate that people appeared to be in general agreement that preservation of the wildlife was and forest was important.

#### Recreational project

As can be noted in Table 6-1, four resource categories were considered in the study with reference to the impact of the smaller recreational project. If the respondents were more willing to trade the resources that would otherwise be flooded in order to obtain the 1400 acre recreational lake, the means of the four

statements would likely be much lower than the means for the multiple-purpose project. However, means dropped only by amounts of 0.4 for wildlife, 0.6 for wooded pasture, 0.7 for the forest, and 0.3 for the prairie potholes from the mean levels obtained for the statements referring to the multiple-purpose project. This seemingly minor drop in the level of statement means between the two projects appeared to indicate that almost equal concern was also felt over the physical impact of the recreational lake. Wildlife again had the highest mean, followed by forest, wooded pasture, and prairie potholes.

The percentages agreeing at a level of agree-5 also declined from the percentages obtained in the case of the multiple-purpose project. The range of decline varied from 11 percent for forest to 7 percent for wooded pastures. Interestingly, the percentage of agree-5 respondents for prairie potholes increased about 2 percent from the percentage stated for the multiple-purpose project. No reason seems apparent for this behavior as the mean for the impact of the recreational project upon prairie potholes was the lowest of all means with a value of 7.3. Likewise, this resource category had the highest disagreement between the two projects with almost 37 percent of respondents disagreeing that preservation of potholes was important.

#### Reasons for agreement

Those respondents who agreed with any of the statements referring to prairie relics or prairie potholes, forest, wildlife,

or the free-flowing stream, were asked to consider 4 or 5 possible reasons for agreement that were provided after each of these general categories. The results of these responses are summarized in Table 6-2.

The range of means varied from 9.4 to 10.5. The least popular reason concerned preserving the prairie relic and pothole acreage for scientific study sites. The most popular reason stated was that respondents enjoyed viewing wildlife, followed closely by enjoyment of the presence and existence of wildlife even though respondents may not go out to see them. Generally, the percentage of agreement was quite high ranging from 92 percent to 100 percent. Ranking of reasons, as listed in Table 6-2, was based upon consideration of means, percentage agreement, and percentage agree-5.

In the 5 reasons relating to prairie relics and prairie pot-holes, the two most popular were enjoyment of natural unforested landscape and enjoyment of vegetation because of diversity, beauty, and virgin character. With forest, the most popular reasons listed were enjoyment of forest because it provides an area of natural beauty and pleasure and because the forest allows possibility of providing outdoor recreation in forms of hiking and nature trails, camping, picnicking, and so on. Wildlife, as mentioned above, was enjoyed for viewing purposes, closely followed by enjoyment of their presence and existence. Wildlife was also felt important to preserve so that future generations can enjoy them. The value of means, percentage of total agreement, and percentage agree-5,

Table 6-2. Summary of responses to reasons

Resource category	Reason	Mean	Standard deviation	% agree	% agree-5	Rank	Summary of reason
Prairie relics and prairie potholes	1	10.0	1.6	96.6	59.1	1	Enjoy natural un-forested landscape
	2	9.4	2.1	91.9	43.6	3	Are valuable scientific study sites
	3	9.6	2.3	92.3	51.1	2	A heritage from the past
	4	10.0	1.9	95.3	59.4	1	Enjoy vegetation because of diversity and beauty
	5	9.6	2.2	92.8	49.8	2	Potholes provide waterfowl habitat
Forest	1	9.9	1.7	96.0	53.5	2	Contact with nature less devoid of man's influence
	2	9.7	2.0	94.2	54.3	3	Provide a heritage to future generations
	3	10.2	1.4	97.8	62.7	1	Provide natural beauty and pleasure
	4	10.2	1.4	98.6	63.8	1	Provides outdoor recreation possibility

Wildlife	1	9.9	1.8	94.5	56.8	3	Is a heritage from the past
	2	10.3	1.4	98.2	64.8	2	Need to preserve so future generations can also enjoy
	3	10.4	1.4	98.2	65.4	2	Enjoy presence and existence
	4	10.5	1.0	100.0	74.4	1	Enjoy viewing wildlife
Free-flowing stream	1	9.9	1.6	96.3	54.3	1	Stream is unique
	2	9.7	1.9	94.7	54.3	2	Enjoy stream for recreation
	3	10.0	1.5	97.9	55.6	1	Stream is a heritage from past since unstraightened
	4	10.0	1.8	95.9	61.7	1	Stream, vegetation, etc. should be preserved in entirety

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were all very close for all 4 reasons referring to the Skunk River. The stream was considered unique in its setting, in addition to being considered a heritage from the past because it was unstraightened. Respondents also felt that the streams and surrounding resources should be preserved in entirety. This last reason, reason 4 for the free-flowing stream, is not entirely a "reason". Reason 4 was inserted to test the notion that the Skunk River by itself (naked per se) was not valued unless the stream was accompanied in a package that included other resources such as the forest and wildlife. This indeed appeared to be the case since the mean value for reason 4 was 10.0, suggesting strong agreement in the sample population.

The high ranking of reasons that expressed beauty, diversity pleasure and naturalness seem to indicate that amenity values, as defined in Chapter I of this study, do exist. In particular, people appear to enjoy at present the beautiful in nature and are conscious that such forms of beauty exist in the central Iowa landscape.

#### Aggregation to obtain an environmental index

Returning to consideration of responses to the 11 statements in Section II of the questionnaire, the mean value of statements can now be used to obtain an index of importance for each category. This index of importance when multiplied by the index of physical impact for the same resource category, as derived in Table 5-1, and summed over all categories, can be used to obtain an aggregated

index of environmental quality. This aggregated index is subsequently used to derive a production-possibility curve, or trade-off curve, between environmental quality and economic development. The procedure is as follows.

If the value 6 is subtracted from each mean, and the difference is multiplied by 2, the agree range of the 11-point scale from indifference (6) to very strongly agree (11) will be converted to a 0 to 10 index, similar to the index of physical magnitude developed in the previous chapter. The value 10 represents very strong importance while 0 represents negligible importance. Table 6-3 provides the results of this procedure. This table is therefore similar to the Leopold Matrix, except that only one activity or column (that of inundation) is considered relevant. Aggregating over all 7 resource categories for each project provides an aggregated index of environmental quality. Comparison of totals in Table 6-3 indicates, by this method of measurement, that the overall environmental impact of the recreational reservoir, by inundation alone, is about 27 percent of the multiple-purpose project environmental impact.

Little consideration should be given to the absolute value of the totals expressed in Table 6-3. The totals can easily be increased, for example by increasing the number of resource categories considered, either by adding new ones or by sub-dividing present ones, or by changing the indices used for measurement of physical impact and importance. The totals should only be used

Table 6-3. Derivation of aggregated index of environmental impact

Resource category	Project	Index of physical magnitude	Index of importance	Multiplication of index values	
				MP	Rec
Wooded parks	MP	5	4.5	22	
	Rec	0	0		0
Prairie relics	MP	2.5	4	10.5	
	Rec	0	0		0
Prairie potholes	MP	4	3	12	
	Rec	2	2.5		5
Forest	MP	6.5	7	45.5	
	Rec	2.5	6		15
Wooded pasture	MP	5.5	6	33	
	Rec	1.5	5		7.5
Wildlife	MP	6	8	48	
	Rec	2	7		14
Free-flowing stream	MP	8	5.5	44	
	Rec	3.5	4.5		16
Totals				215.0	57.5



to provide a relative estimate of the environmental impact of alternative projects. A rough check on the relative magnitude of the totals can be made by calculating the percentage of area flooded by the recreational lake, 1400 acres, to the total acreage of the multiple-purpose project, 5200 acres with sub-impoundments. This percentage is equal to about 27 percent, identical to the percentage of the smaller total index value relative to the larger as calculated in Table 6-3.

#### Explanatory variables from regression analysis

Thirteen independent variables were hypothesized to affect responses regarding the 11 statements in Section II of the questionnaire.<sup>1</sup> These variables are listed in Table 6-4 which presents the correlation matrix for these variables. The square root transformation of number of members of household and distance to Soper's Mill were used because of the skewness of the frequency functions. Likewise, a logarithmic transformation was made of the income mean.

Fourth root values were used for transforming years at present address of the household head and years lived in Iowa of the head. Since there exist zero values for these variables

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<sup>1</sup>The advice and counsel of Dr. Wayne Fuller, Department of Statistics, Iowa State University, Ames, Iowa, is greatly appreciated in formulating dependent and independent variables used in this study. Dr. Fuller also aided in the interpretation of the regression equations that were subsequently developed.

Table 6-4. Correlation matrix for independent variables

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 Age of head	1	-.35	-.38	.12	.07	.09	-.30	-.10	-.13	.08	.08	.63	.65
2 Grade of head		1	.09	-.09	.09	-.20	.39	.60	-.12	.00	-.12	-.25	-.50
3 (Members of $\frac{1}{2}$ household)			1	.07	-.04	-.10	.38	-.06	.21	-.06	.13	-.12	-.25
4 (Distance to Soper's Mill) $\frac{1}{2}$				1	.20	-.19	-.05	-.22	.12	.47	-.03	.01	.07
5 R lived in city greater than 10,000 <sup>a</sup>					1	-.56	-.03	.10	.01	.28	-.24	-.02	-.03
6 R lived on a farm <sup>a</sup>						1	-.02	-.14	-.06	-.27	.42	.10	.14
7 Natural logarithm of income mean							1	.15	.16	-.07	.10	-.01	-.26
8 Head is a professional								1	-.22	-.07	-.14	-.16	-.37
9 Head is a craftsman									1	.04	-.11	-.12	-.04
10 Present address in Des Moines										1	-.29	-.06	-.01
11 Present address on farm											1	.17	.13
12 (Years at present address of head) $\frac{1}{4}$												1	.55
13 (Years lived in Iowa by head) $\frac{1}{4}$													1

<sup>a</sup>R refers to respondent. Both variables 5 and 6 refer to where respondent spent half or more of life.

problems are posed in the use of logarithms. However, the fourth root of a number is roughly equivalent to the natural logarithm of the same number, and was therefore used to provide a more normally distributed frequency function for years at present address of the head. The fourth root transformation was used for years of residency in Iowa of the head to reduce the high correlation with age of head.

Zero-one dummy variables were employed to represent six of the independent variables. For example, if the occupation of the household head was listed as "professional", the number 1 was given to represent these households and the number zero was given to all other households. Similarly, the number 1 was given to households with a "craftsman" as the head and zero to all remaining households, to create a second independent variable. No other occupations, as can be seen in Table D-7, Appendix D, were felt sufficiently well represented to warrant creating additional independent variables. Zero-one dummy variables were similarly used to represent households in which the respondent had lived in a city greater than 10,000 for half or more of his (her) life, or had lived on a farm for more than half of a lifetime. Zero-one variables were also used to represent rural addresses and residents of Des Moines (including Urbandale). It was felt that a rural address would well represent farmer and rural attitudes. A Des Moines or Urbandale address would represent a "big city" attitude.

The dependent variables, representing the responses to the

11 statements, took the form of the same coded values used to determine statement means. For example, disagree-5 was represented by 1, and agree-5 was represented by 11, as discussed previously in this chapter.

The purpose of multiple regression analysis in this section was to discover which independent variables were related to the statement responses. An additional purpose was to construct an equation for each statement that would provide the best prediction for values taken by the statement. A step-wise regression procedure was employed to achieve these purposes. The first step was to discover the independent variable with the highest correlation to the dependent variable. Simple regression was fitted and a linear relationship derived. If significant, using the F-test, the remaining list of independent variables was then screened to determine which second variable had the highest partial regression with the dependent variable while holding the level of the first variable constant. A multiple regression equation was fitted and the significance of the new variable plus the first one were determined. If still significant, a third independent variable was chosen which had the highest partial regression given the level of the first two chosen. Significance levels of the new and original independence variables were tested. The procedure was continued until no additional significant variables were discovered. If independent variables were closely related to each other, only one was required. Therefore, if two were closely

related and both significant, the last one to enter the equation was excluded.

The above routine was performed routinely by computer programs available to the Iowa State Statistical Laboratory. Equations were developed relating independent variables to statement values for each statement. These equations are presented in Table 6-5,<sup>1</sup> along with the coefficient of determination,  $R^2$ , and the standard error, located in brackets beneath each slope coefficient. The level of significance of each variable is also indicated.

Of interest is to note those variables which were not at all related to the statement responses. These variables were age and education of the head of household, distance, respondent having lived on a farm for majority of life, occupations, and number of years at the present address. Distance, in particular, was expected to have a negative relationship.

Of the six variables that were significantly related to statement responses, only the size of the household and present address

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<sup>1</sup>Entries in each row in Table 6-5, and in following Tables 6-7, 6-12, and 6-14, represent one equation in the form of:

$$\hat{y} = a + \sum_{i=1}^m b_i x_i$$

where for any particular row:

$\hat{y}$  = estimated value of the dependent variable,  
 $a$  = value of the constant,  
 $b_i$  = slope coefficient for independent variable  $i$ ,  
 $x_i$  = value of the independent variable  $i$ ,

and where

$i = 1$  to 13.

Table 6-5. Results of multiple regression with statements

Statement number and resource category	Project	R <sup>2</sup>	Constant
1 Wooded parks	MP	.027	8.367
2 Prairie relics	MP	.046	9.786
3 Prairie potholes	MP	.043	8.451
4 Prairie potholes	Rec	.061	8.508
5 Forest	MP	.019	9.744
6 Forest	Rec	.038	9.131
7 Wooded pasture	MP	.041	6.707
8 Wooded pasture	Rec	.067	9.960
9 Wildlife	MP	.022	10.03
10 Wildlife	Rec	.054	13.59
11 Free-flowing stream	MP	.032	10.65

<sup>a</sup>\*\*\*\* = level of significance of .005.  
 \*\*\* = level of significance of .001.  
 \*\* = level of significance of .025.  
 \* = level of significance of .05.  
 no stars = level of significance of .10.

Independent variable <sup>a</sup>					
3	5	7	10	11	13
(members of house- hold) <sup>1/2</sup>	R lived in city great- er than 10,000	ln of income mean	Present address in Des Moines	Present address on farm	(Years lived in Iowa by head) <sup>1/4</sup>
				-1.367 (.533)**	
-1.020 (.451)*				-1.214 (.549)**	
-0.841 (.448)	1.072 (.412)****				
-1.132 (.463)**	1.261 (.426)****				
				-0.866 (.399)*	
				-1.472 (.481)****	
				-0.962 (.458)*	0.959 (.363)***
-1.237 (.413)****			1.093 (.415)***		
				-0.928 (.399)**	
		-0.431 (.228)		-1.297 (.438)****	
-1.209 (.428)****					

on a farm were frequently related, always negatively. Size of household was not expected to be related at all, and was therefore interesting to note. However, size of household was only related to those resource categories which were least preferred on the basis of statement means, as shown in Table 6-1. On the other hand, respondents who presently lived on farms were negatively related to the most preferred resource categories, especially forest and wildlife. This provides support to the view that rural people do not value forest and wildlife as highly as urban people since the rural people have the "outdoors" in their own backyard, and must content with nature frequently to make a living.

Respondents who had lived in a large city half or more of their lives were positively related to statement responses regarding potholes. This researcher leaves it to others to suggest why such people might like potholes, other than they like to hunt waterfowl! Income entered once, and only at the 1 percent level of significance. It was originally hypothesized that income was positively related to statement responses, but this hypothesis was not supported. Persons who lived in Des Moines were positively related to statements about the wooded pasture flooding of the recreational lake. Wooded pasture also seemed to be more highly valued by those who had lived in Iowa for longer periods of time.

The values of  $R^2$  for all 11 equations were low, indicating that these variables accounted for only a small fraction of the



total variation in the statement responses. This was not considered discouraging because the general level of statement means was high, indicating that the population at large felt strongly that preservation of the resource categories was important. All equations included either family size and present address on farm, or both, as an independent variable, but these variables did not "explain" much of the variation in terms of high values for the coefficient of determination.

#### Ranking of Resource Categories by Point Allocation

Resource categories were ranked previously by comparing statement means and percentages of respondents who agreed-5 to the statements in Section II of the questionnaire. Results are now presented of the alternative method of ranking, that of allocating 100 dollars between the seven resource categories, as obtained from Section III of the survey questionnaire. Five respondents refused to answer this question.

Column 1, Table 6-6, provides the mean number of points allocated to each resource category. The rank of resource categories, in their relative importance for providing amenity services, is different from the rank as determined by comparison of statement means, as can be seen in columns 6 and 8. Wildlife is still rated first under the ranking system based on mean of points. However, second in importance is wooded parks, supplanting forest to third place. The free-flowing stream remains fourth. Prairie relics are

Table 6-6. Allocation of points

	Column			
	1	2	3	4
Resource category	Mean number of points <sup>a</sup>	Standard deviation	Absolute frequency with zero	Absolute frequency with 100 <sup>b</sup>
Wooded parks	21.5	25.0	90	16
Prairie relics	6.2	9.5	171	0
Prairie potholes	4.2	6.8	189	0
Forest	16.8	20.6	105	8
Wooded pasture	5.6	8.4	176	0
Wildlife	31.4	27.2	47	25
Free-flowing stream	13.5	18.8	120	6

<sup>a</sup>Column will not add to 100 because responses of 98, 99, or 100 for any resource category was coded for analysis as 98.

<sup>b</sup>The value 100 can represent 98, 99, or 100.

<sup>c</sup>From Table 7-1.

Column					
5	6	7	8	9	10
Maximum <sup>b</sup>	Rank according to mean of points	Rank according to percentage agree-4,5 in state-ments	Rank according to mean of state-ments	Percentage agree-4,5 to state-ments <sup>c</sup>	Mean of statements <sup>c</sup>
100	2	4	5	55.2	8.2
50	5	6	6	43.2	8.1
33	7	7	7	36.0	7.6
100	3	2	2	69.7	9.7
50	6	5	3	54.9	9.0
100	1	1	1	79.3	9.9
100	4	3	4	56.1	8.8

fifth with potholes remaining last. However, wooded pasture is now relegated to sixth place from its rank of third in relative importance according to the statement means.

Table 6-6 also includes a column, column 3, indicating the absolute frequency of respondents who allocated zero points to a resource category. This is inversely related to the number of points. Only 47 respondents failed to give any points to wildlife, while 189 respondents gave no points to potholes. There were 105 respondents who allocated no points to the resource category of forest.

Twenty-five respondents, as shown in column 4, allocated all their points to wildlife, the resource category which most frequently received all the 100 points by itself. Column 5 shows that prairie potholes were never allocated any more than 33 points, the lowest of all categories.

The last two columns, columns 9 and 10, in Table 6-6 were obtained from Table 6-1, and used to derive ranks of resource categories from information about statements. The ranking varies depending upon use of the statement means of use of total percentage of respondents who agreed 4 and 5 on the statements. The problem remained of choosing the column which would "best" rank the resources for their contribution to amenity services. It was felt that the ranking method based upon the mean of points was inadequate because wooded parks were ranked higher than forest. Since there were only about 70 acres of parks compared to 1300 acres of

forest, and since even larger parks can be made out of the forest, the rank based on mean number of points was rejected for the final ranking system. The problem of choosing a better one was resolved by correlating column 1 with columns 9 and 10, and column 9 with 10. The correlation coefficient relating column 1 to column 9 was significant at the 0.8 percent level while the correlation coefficient relating column 1 to column 10 was significant only at a 5.9 percent level. On the other hand, columns 9 and 10 were correlated with a significance level of 0.1 percent. Hence, since column 9 correlated so highly with both columns 1 and 10, column 9 was chosen to represent the final ranking of the resource categories. Column 9 is the total percentage of respondents who agreed 4 and 5 to the statements. Correlation of all columns was also performed with the percentage of those respondents who agreed-5 to the statements, but significance levels were poorer.

In summary, after considering all ranking possibilities, the final ranking of resource categories placed wildlife first, forest second, and the free-flowing stream, wooded parks, and wooded pasture about equally tied for third place. Prairie relics came in fourth, with prairie potholes at the bottom, ranked fifth in relative importance for providing amenity services.

#### Explanatory values in point allocation

Multiple regression models were also developed for determining variables that were related to the allocation of the 100 points between the 7 resource categories. The same 13 independent variables

as employed previously in regression analysis with statements were employed. Results are summarized in Table 6-7. Highlights of Table 6-7 are now discussed.

The values for  $R^2$  and general levels of significance were low. Age of head and grade of head were positively related to prairie relics, while in Table 6-5, these variables were not found related to any of the statement responses. Distance was negatively related to prairie potholes but only at a 10 percent level of significance. Size of household and years at present residence were negatively related to wildlife. It appears that larger households have a general negative attitude to most resource categories, as shown in Table 6-5 and Table 6-7. Households with present addresses in Des Moines and on farms were positively related to wildlife. This contrasts with Table 6-5, where a rural address was negatively related to the wildlife statement. However, the situations are different since no quantity measures are involved in the allocation of points. Rural persons may still enjoy wildlife more than other categories, but also believe that the effect of inundation upon the stock of wildlife will be negligible or slight.

Table 6-7. Results of multiple regression with allocation of points

Resource category	R <sup>2</sup>	Constant	Independent variable <sup>a</sup>						
			1	2	3	4	10	11	12
			Age of head	Grade of head	(Members of house-hold) <sup>1/2</sup>	(Dis-tance to Soper's Mill) <sup>1/2</sup>	Present address in Des Moines	Present address on farm	(Years at present address of head) <sup>1/2</sup>
Wooded parks	.016	14.101							5.220 (2.64)*
Prairie relics	.062	-6.947	0.075 (.035)*	0.750 (.192)****					
Prairie potholes	.014	6.608				-0.508 (.274)			
Forest	.016	23.93	-0.151 (.077)*						
Wooded pasture					No significant variables				
Wildlife					-8.370 (3.79)*		11.04 (3.92)***	11.51 (4.85)**	-7.903 (2.81)***
Free-flowing stream	.013	21.82		-0.676 (.381)					

<sup>a</sup>\*\*\*\* = level of significance of .005.  
 \*\*\* = level of significance of .001.  
 \*\* = level of significance of .025.  
 \* = level of significance of .05.  
 no stars = level of significance of .10.

Empirical Results Related to the  
Green-belt Park System

Visits and recreational activities

A green-belt park system had been suggested as a method of preserving the seven resource categories while providing a facility for outdoor recreation activities in which a stream would be the center of attraction. Table 6-8 provides a summary of expected visitation to the green-belt area as obtained from Section IV of the survey questionnaire. Only about 12 percent of the households stated that they would never visit the area. Visitation was skewed to the left since the median level of 9.5 visits was considerably less than the mean value of 20.1 visits provided each year by a household. Inspection of Table 6-8 provides little indication about total green-belt attendance that the 9 county study area would provide when the sample visitation is extrapolated to the total population. Although there are about 13 percent who will provide 51 or more visits from each household per year, this could be provided by local households who would make frequent use of the area.

It was therefore surprising, to this researcher at least, that when extrapolated to the total population, a total of about 2,790,000 visits would be made to the green-belt area! This represented about a 10-fold increase in visitation to that which could "reasonably" be expected to visit such an area. The value of total visits above represents about 5 or 6 visits per year of



Table 6-8. Expected visits to the Green-belt Area

Number of visitor-days <sup>a</sup> per year provided by each household	Absolute frequency	Percent of total
0	34	11.6
1-5	63	21.4
6-10	52	17.7
11-20	59	20.0
21-30	23	7.9
31-50	25	8.5
51-75	19	6.4
76-100	13	4.5
100-120 (maximum)	6	2.0
Total	294	100.0
Mean	= 20.1	
Standard deviation	= 24.1	
Median	= 9.5	

<sup>a</sup>A visitor-day is a visit by one person of less than 24-hours duration. For example, a household providing 10 visitor-days could mean a household of one person providing 10 different day visits, or a household of two persons providing 5 different day visits together.

every resident in the sample area.

Reasons need now be stated that could possibly account for the number of actual visits of each household to be overestimated by such a large amount. One reason appears to be undue optimism on the part of the respondents. Although visitation intentions may be good on their part, they can never realistically hope to provide as many visits as stated. A second reason could be the public good nature of an outdoor recreation facility. If it is desired, it is to their advantage to overstate their preferences. A third reason hypothesized is that the size of sample was too small, especially in the outer stratum. For example, two respondents, one in Des Moines and the other in Marshalltown, each stated that their households would provide a total of 100 visits per year. When extrapolated to the outer stratum population, these two households therefore accounted for about 204,000 visits. A fourth reason could be, as stated previously, to please the interviewer.

Hence, there appears to be no doubt that the value of 2.8 million visits is an overestimation. The magnitude of overestimation, however, can be interpreted as an initial indicator of the desirability of the green-belt system.

The 34 respondents who stated that they would never visit the green-belt area were asked their reasons for zero attendance. The most popular reason listed was "other", with about 65 percent of these respondents stating that they were "unable to get there". The next most popular reason was very little participation in

outdoor recreation activities. Third and fourth popular reasons were not enough time and too far. Preference of a lake was least popular with only 2 respondents checking this possible reason.

Households which would provide visits were asked to state the recreational activities that household members would participate in at the proposed green-belt area. Responses are recorded in Table 6-9. The most popular activity was picnicking, with 96 percent of all households. The second most popular activity was that of observing wildlife. The popularity of observing wildlife indicates that the green-belt system is expected to accomplish the preservation of wildlife, while allowing the public to observe the wildlife. The mean number of activities per household was 6.4.

#### Estimation of monetary benefits

Monetary benefits were estimated by determining total willingness to spend from each household. Table 6-10 summarizes results of the dollars households would be willing to spend per year to visit the green-belt system or to aid in its establishment. About 25 percent of the respondents stated that they would spend 10 dollars or less. The maximum amount stated was 250 dollars. About 13 percent of the households would spend 100 dollars or more. The larger sums of 25, 50, 100, and 200 dollars were quite popular, indicating that people were willing to spend household budgets but could not state precise amounts.

When extrapolated to the total study population, a total willingness to spend of 4,042,000 dollars was obtained. Four

Table 6-9. Anticipated recreational participation by activity

Type of activity	Absolute frequency of participation <sup>a</sup>	Percent of 260 households	Rank of popularity
picknicking	250	96	1
driving for pleasure	208	10	3
fishing	117	64	4
hiking	161	62	5
biking	75	30	10
observing wildlife	231	89	2
camping	124	48	7
canoeing	76	30	9
mushroom hunting	127	49	6
sledding	92	35	8
ice skating	60	23	11
skiing (snow)	43	17	13
other <sup>b</sup>	48	18	12

Mean activities per 260 households = 6.4

<sup>a</sup>From sample of 260 households who stated they would visit the area. Members of households may participate in more than one activity in any one visit and/or may distribute activities over various visits.

<sup>b</sup>The list of others and frequencies were hunting (10), swimming (9), cycle riding (6), photography (4), horseback riding (3), playground activities (3), boating (3), golfing (2), observing plant life (2), and single responses of Indian relic hunting, snowshoeing, kite flying, tennis, and painting pictures. Some respondents listed more than one "other".

Table 6-10. Willingness to spend to visit or aid in establishment of Green-belt Area

Dollars per year	Absolute frequency	Percent of total
0	74	25.2
1-3	20	6.8
4-6	38	12.9
7-10	35	11.9
15-16	15	5.1
20	9	3.1
25-26	21	7.1
30-40	11	3.9
50	25	8.5
60-75	8	2.7
100	22	7.5
150	1	.3
200	5	1.7
250	1	.3
No response, don't know	9	3.1
Total	294	100
Mean of 285 responses = 25.46		
Standard deviation = 40.1		
Median = 9.97		

million dollars is therefore a maximum value of monetary benefits that can be attributed to the green-belt park system, based on these results.

This value, although it is likely to appear too high for some observers, is more difficult to explain why it cannot be considered as an approximation of the true maximum value of benefits. Again, people may overstate replies because of the public good nature of the facility. On the other hand, there is incentive to understate their responses, as argued in the previous chapter. The dollar response can be considered high because of undue optimism, and other factors, as discussed previously. However, respondents were asked to state the most money they would spend. It is not necessary that they spend what they say, since if the facility is made available, those who stated large amounts may never be required to actually spend the amount stated. Unfortunately, there appears to be no way that the 4 million dollars of benefits can be tested as being an accurate estimate of total benefits unless the green-belt system is actually built and, after subtracting transportation costs and related variable visit expenses, the remainder is collected by a discriminating monopolist.

Those 25 percent of respondents who refused to spend any dollars were requested to state their reasons for zero expenditures. Table 6-11 summarizes these responses. Unable to afford was the most popular, with unable to use or would not use as the second most popular reason. Thirteen people (including one respondent

Table 6-11. Reasons cited for zero dollar response

Reason	Absolute frequency	Percent of total
Cannot afford	20	6.8
Other areas available	9	3.1
Not worth spending money on	2	.7
Should not have to pay	12	4.1
Other <sup>a</sup>	24	7.5
Not applicable (would pay)	211	71.8
No response	18	6.1
Total	296 <sup>b</sup>	100

<sup>a</sup>Other reasons and frequencies were unable to or would not use area (14), prefer a lake (4), area should be left as is (3), entry fee should support it (1), other facilities available that are free (1) and do not know enough about area (1).

<sup>b</sup>Two respondents provided two reasons, therefore, the column will not add to 294.

who preferred free facilities) would not pay if entry fees were charged, and would likely therefore not visit the green-belt area. Since only thirteen respondents provided this reason, it does not appear that the willingness-to-pay question was generally misinterpreted by respondents believing that the question referred only to entrance fees. On the other hand, if the question were generally misinterpreted in this manner, total benefits would be even higher since transportation and other visit related expenses could still be added.

#### Visitation and benefit prediction models

As with responses to the statements and allocation of points, multiple regression equations were developed to aid in identifying household characteristics that were related to visitation and willingness-to-pay. The equations obtained are summarized in Table 6-12. Four variables were found significantly related to visitation. Age of head and distance were negatively related, as expected. Size of household was positively related, an indication that larger households would provide more visits per household. Households with a craftsman at the head were also positively related, but at a lesser level of significance.

Visitation from any particular household in a regional area can now be predicted with the use of the equation by entering the relevant magnitudes of household characteristics. Total visitation from a particular regional area, or even a particular age group of the public, can be estimated by determining average household



Table 6-12. Results of multiple regression with visitation and willingness to spend

Dependent variable	R <sup>2</sup>	Constant	Independent variable <sup>a</sup>				
			1	3	4	9	
			Age of head	(Members of house-hold) <sup>1/2</sup>	(Distance to Soper's Mill) <sup>1/2</sup>	Head is a craftsman	(Visits to green-belt) <sup>1/4</sup>
(Visits to green-belt) <sup>1/4</sup>	.376	2.055	-0.011 (.002)****	0.588 (.097)****	-0.159 (.027)****	0.232 (.114)*	
(Willingness to spend to visit or establish green-belt) <sup>1/4</sup>	.165	3.284	-0.019 (.004)****		-0.158 (.042)****		
(Willingness to spend to visit or establish green-belt) <sup>1/4</sup>	.383	0.120					0.852 (.069)****

<sup>a</sup>\*\*\*\* = level of significance of .005.

\* = level of significance of .05.

characteristics of age of head, size, and fraction of heads who are craftsmen in the area. After determining distance, all 4 values can be entered into the equation, and the result multiplied by the number of households in the area. Since it was felt that visitation was overestimated, the visitation prediction equation will also overestimate. However, the equation will provide a relative indication of visitation from different public subgroups as determined by age of head, size of household, distance, and occupation of head.

The coefficient of determination,  $R^2$ , was about .38, notably higher than previous regressions, showing that more of the variation in visitation could be accounted. In regards to the equation developed for willingness to spend, the value of  $R^2$  declined to .165, indicating that a less satisfactory fit had been obtained.

Only age of head and distance to Soper's Mill were found to be related to willingness to spend, both negatively. It was expected that income would be positively related, but this did not seem to be the case, at least in the sample available. Willingness to spend, however, was highly positively correlated with the number of visits, as expected. This is shown in the last row or equation of Table 6-12 where visits to the green-belt was employed as an independent variable to predict willingness to spend. A value for  $R^2$  of .38 was obtained in this last equation.

Ranking of Development Alternatives  
by the Public

The public was also asked to rank 4 development possibilities that existed in the Skunk River valley and periphery between Ames and Story City. Results are presented in Table 6-13. The green-belt area was first choice for 46 percent of the respondents and was first or second choice for about 87 percent of all respondents. The alternative of leaving the area in private control in terms of first choice was second most popular of the four possibilities, with the recreational lake third, and the Corps of Engineers multiple-purpose project fourth. It was interesting to note that 18 percent of the respondents also gave fourth choice to leaving the area in its present state of control, suggesting that some sort of development alternative should be explored. The multiple-purpose project seemed unpopular since 64 percent of respondents desired it least of the four possibilities.

A regression analysis was also employed to determine variables related to ranking of the development alternatives. The results are summarized in Table 6-14. The value of the dependent variable took the form of 1 for first choice of the development alternative, 2 for second choice, 3 for third choice and 4 for fourth choice. Hence, the signs of the coefficients must be interpreted differently from previous tables presenting regression results. A negative coefficient indicates that an increase in the level of the independent variable results in a lower value for the dependent

Table 6-13. Ranking of development alternatives

Type of development	1st choice		2nd choice		3rd choice		4th choice		No response <sup>a</sup>	
	Abs. freq.	% of total	Abs. freq.	% of total	Abs. freq.	% of total	Abs. freq.	% of total	Abs. freq.	% of total
Green-belt	136	46.3	119	40.5	27	9.2	7	2.4	5	1.7
Leave area in private control	88	29.9	80	27.2	70	23.8	53	18.0	3	1.0
1400 acre recreational lake	44	15.0	77	26.2	133	45.2	25	8.5	15	5.1
Multiple-purpose project	25	8.5	16	5.4	44	15.0	189	64.3	20	6.8

<sup>a</sup>"No response" refers to respondents who could not or refused to rank all of the alternatives.

Table 6-14. Results of multiple regression with ranking of development alternatives

Type of development	R <sup>2</sup>	Constant	Independent variable <sup>a</sup>				
			1	6	9	10	11
			Grade of head	R lived on farm	Head is a craftsman	Present address in Des Moines	(Years at present address of head) <sup>1/4</sup>
Green-belt	.082	2.378	-0.053 (.014)****			-0.252 (.098)**	
Leave area in private control	.041	2.903		-0.284 (.153)			-0.267 (.110)**
1400 acre recreational lake	.043	2.206			-0.281 (.152)		0.221 (.088)**
Multiple-purpose project			No significant variables				

<sup>a</sup>\*\*\*\* = level of significance of .005.

\*\* = level of significance of .025.

no stars = level of significance of .10.

variable, showing increased preference for the alternative under consideration.

Grade of head was negatively related to the green-belt rank at a 0.5 percent level of significance, indicating that households with higher educated heads preferred the green-belt area. Residents of the Des Moines were similarly related.

Those respondents who had lived on a farm for half or more of life were negatively related to the ranking of "leave as is", possibly reflecting a negative rural attitude to government development projects. Years at present address were also related negatively, as well as being more significant than rural attitudes.

The recreational lake appeared to be preferred by households with a craftsman as the head. Years at present address was the only positively related variable in Table 6-14, showing that the recreational lake was preferred less than other alternatives by those of longer residency. No significant variables were related to the multiple-purpose project.

The direct presentation of survey results has now been completed. Now addressed is the problem of deciding the best natural resource development alternative to undertake.

#### Application of Performance Criterion

This final section of Chapter VI presents the trade-offs identified between environmental study and economic development in order to apply the broad productivity criterion in addition to describing application of the maximum GNP criterion. The broad

productivity criterion is discussed first.

Table 6-3 derived an aggregated index of environmental impact for the multiple-purpose project and recreational lake. Three points are now available for the environmental quality axis, namely zero (or near zero) for the green-belt system, 57.5 for the recreational lake, and 215 for the multiple-purpose project.

With reference to the economic development axis, consideration is first given to the Corps of Engineers multiple-purpose project. In 1968, the Corps estimated total net benefits of about 525,000 dollars from flood control, water quality enhancement, and provision of outdoor recreation (81, p. 31). A discount rate of  $3\frac{1}{4}$  percent was employed by the Corps and a 100 year life of project was assumed to obtain a benefit-cost ratio of 1.6:1. The Ames Reservoir Environmental Study (ARES), soon to be published in entirety, has revised the Corps values by making "technical corrections", mainly by raising the interest rate to  $4\frac{5}{8}$  percent, and altering flood control benefits to reflect revised flood frequencies, yields, and prices. These corrections reduced the net annual benefits to about 275 thousand dollars, resulting in a benefit-cost ratio of about 1.3:1. Currently, further analysis by ARES appears to be showing that net benefits from the multiple-purpose project are negative. The benefit-cost ration is more likely to be about 0.5:1 when a higher discount rate of 7 percent is employed, project life is reduced to 50 years (benefits cannot "reasonably" be estimated more than 50 years ahead), water quality

benefits are lowered since low flow augmentation is unlikely to achieve claims, and other factors are incorporated. Hence, at present, net benefits are very controversial.<sup>1</sup>

The Corps of Engineers have not (July, 1973) responded to the ARES estimates of benefits and costs. Since there appears to be some likelihood that the Corps of Engineers will readjust their values, it does not seem reasonable in this study to choose any estimate of net benefits until the project has been resubmitted to Congress for funding. Therefore, no net value of benefits is presently available to represent the multiple-purpose reservoir on the economic development axis.

ARES has also calculated the economic benefits of the recreational reservoir, estimating a benefit-cost ratio of about .25:1. Therefore, no net value is also currently available for the recreational reservoir to place upon the economic development axis. Hence both projects cannot be considered in the broad productivity criterion as developed for use in this study.

With respect to the maximum GNP criterion, both the multiple-purpose project and the recreational lake appear, as stated above, to provide no additions to GNP if constructed since benefit-cost ratios are likely less than unity. On the other hand, the

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<sup>1</sup>ARES values from Tables 6-3-2 and 6-3-6 in a draft version of a chapter on the revised benefit-cost analysis of the Ames Reservoir project (44b).



green-belt park system appears to be a reasonable development alternative because of a possible excess of benefits over costs. ARES has recently calculated a tentative present total cost of about 4.4 million dollars for an intensive green-belt development. Benefits, using 2.00 dollars per visitor-day (pricing by "government decree", as described in Chapter III) and an initial visitation per year of 150,000 visitors, were calculated to have a present worth of about 4.25 million dollars, when discounted to the present at 7 percent over a 50 year period of time.<sup>1</sup>

It was argued in Chapter V that the appropriate discount rate for discounting environmental quality benefits should reflect the time preference of society. Reasons for preserving resource categories were cited in this chapter suggesting that the public enjoys the resources along the Skunk River primarily for beauty and pleasure in the present. There is no reason from the survey to suggest that enjoyment of beauty and pleasure (amenity services) will decline in the future and not be demanded by the public at future points in time. Therefore an appropriate discount rate is zero or near zero, to reflect future time preference of individuals and the public in general.

A possible excess of benefits over costs for the green-belt

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<sup>1</sup>Values in this paragraph were obtained from an extension of the Ames Reservoir Study which considered more thoroughly the feasibility of a green-belt park system at the Ames Reservoir site (92)..

alternative can be illustrated as follows. Suppose, for simplicity, that amenity benefits can be quantified in monetary terms and will grow at 3 percent per year because of increasing demand and population growth. If a discount rate of 3 percent is also chosen, to accommodate inflation and for easy arithmetic (reflecting a zero real rate of discount), and a 50 year planning horizon, application of present value formulas show that amenity benefits in the initial year need only be equal to about 90 thousand dollars to obtain a benefit-cost ratio for the green-belt which is approximately unity (at costs of about 4.4 million dollars).<sup>1</sup> It was shown in this chapter and study that total willingness-to-pay, in the one year of 1973, was about 4 million dollars. The value of 90 thousand dollars is much lower. Hence, even if 4 million dollars is accepted as a gross overestimate of benefits, it is more difficult to say that 90 thousand is also an overestimate.

Additionally, using 2.00 dollars per visitor day and assuming that total green-belt benefits (2.00 dollars times number of visitors) will grow at 3 percent per year, discounted at 3 percent (same as above), and a 50 year planning horizon, only about 45,000 visitors are needed in the initial year to obtain a benefit-cost ratio which is about unity. If the planning horizon is lengthened (which can be very easily justified if the green-belt is to preserve

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<sup>1</sup>This approach parallels the approach of Krutilla et al. (50) in their study of benefits at Hell's Canyon, discussed in Chapter III.

the resource categories for future generations) the initial benefit values can be even lower. Furthermore, the green-belt system will preserve the option of building a reservoir in future years if tastes, preferences, and prices change. However, reservoir construction takes away the option to build the green-belt park system if the reservoir is found to be an investment which does not contribute to economic development.

It therefore appears that the benefit-cost ratio for the green-belt system is greater than unity, and possibly considerably greater than unity. How much greater cannot be said with present data. It therefore seems that the green-belt area is a development possibility which favorably meets the criteria of economic performance that were chosen for application in this study.

## CHAPTER VII. SUMMARY AND CONCLUSIONS

The model developed in this study has been applied in the Ames Reservoir and empirical results obtained. It is now possible to assess the entire study in terms of its objectives, achievements, limitations, and additional research required.

### Summary

The problem of identifying and measuring the effect of proposed reservoirs upon environmental quality was approached by inquiring into the nature of amenity services flowing from natural resources at reservoir sites. Procedures for incorporating amenity values into the evaluation of alternative resource development possibilities were developed by use of the maximum GNP and broad productivity criteria. A public survey was designed which served to rank the contribution of seven resource categories to amenity values and to provide estimates of the magnitude of amenity benefits arising from preservation so that a fuller knowledge of benefits and costs of the proposed Ames Reservoir could be made. The study is now summarized by direct reference to each of the study objectives as presented in the first chapter.

### Achievement of study objectives

The first objective was to define the nature of environmental quality in terms of its meaning and economic characteristics. To attain this objective, environmental quality was interpreted to mean the level of aesthetic and amenity services provided

by natural resources. Aesthetic services were considered to be those characteristics of natural resources appreciated by people because of their beauty. Amenity services referred to pleasant and agreeable qualities of natural resources which make life more enjoyable. Aesthetic and amenity services were labeled amenity services throughout the study for simplicity purposes. To place environmental quality in an economic context, the term "habitat" was first explored in an ecological setting. The ability of the human "habitat" or environment to withstand shocks created by man's demands for other goods and services while providing desired amenity services at a constant level was interpreted as the maintenance of environmental quality.

Chapter II explored characteristics of amenity services which did not permit the price system to allocate resources to meet demands for amenity services. Public good characteristics of amenity services were shown to result in the inability of the price system to consider amenity values. Amenity services are characterized by non-competing consumption and hence preferences, reflected in prices paid, do not need to be revealed to enjoy the service if provided. Natural resources at reservoir sites in Iowa were broadly identified for possible roles in providing amenity services. Natural resources subsequently considered in the analysis were wildlife, forest, the stream itself, wooded pasture, wooded parks, and remaining remnants of Iowa prairie and potholes. These would all be destroyed or damaged if the Ames Reservoir were built.

The second objective of this study was to review alternative methods for determining the magnitude of environmental quality objectives and benefits. Before this objective could be achieved it was necessary to review and choose one or more economic criteria which could be adapted to incorporate environmental quality objectives into a multiple social objective decision making framework. Out of five criteria discussed, two were selected, namely the broad productivity criterion and the maximum GNP criterion. More than one was felt necessary because in the case of amenity services none of the five were satisfactory by themselves. The chosen criteria did not depend upon the measurement of utility, while equity considerations could be noted if desired. Once criteria for economic performance were chosen methods of determining the magnitude of amenity services and subsequent benefits could be explored.

Since non-market and indirect techniques existed for monetary quantifying non-priced services such as outdoor recreation and improved states of water and air quality, the potential of adapting one or more of these methods to the problem of measuring amenity benefits at reservoir sites was reviewed in Chapter III. A willingness-to-pay model was chosen for application of the maximum GNP criterion. In reviewing alternative models reference was made to conceptual problems in the GNP approach, especially consumer surplus and discounting, used extensively in benefit-cost analysis. The model chosen employed direct interviews of potential users of

a green-belt area which would preserve most of the natural resources otherwise to be flooded by the Ames Reservoir. Respondents would be asked to state maximum willingness to spend in visiting the green-belt area or aiding in its establishment. These potential expenditures represented the monetary worth of preserving the resources and could be used as benefits in the benefit-cost analysis of green-belt feasibility.

A second possibility for estimating the magnitude of environmental quality objectives existed in aggregation techniques used in the preparation of environmental impact statements, as required to accompany Federal projects. Two such existing comprehensive methods were reviewed (Chapter IV) in regards to the possibility of incorporating environmental impact statement techniques into application of the broad productivity criterion, for measuring amenity services on the environmental quality axis. Goods and services resulting from economic development by reservoir construction were chosen to be represented by net benefits from project benefit-cost evaluation procedures. A production-possibility curve could then be derived for alternative production possibilities using the natural resources at, and including, the reservoir site, as the resource inputs.

The production-possibility curve would isolate trade-offs which could be compared by use of the opportunity cost concept. The broad productivity criterion was hence felt useful, despite indeterminacy if operating on the frontier, because of the

possibility (termed Pareto-betterment) of increasing production of one good or service while holding the other constant by removing institutional restraints. Because of institutional or other restraints all production possibilities may not have been considered by planners in the case of the Ames Reservoir.

The third objective was to develop a methodological framework to incorporate environmental quality objectives into natural resource development evaluation procedures. This objective was achieved simultaneously with achievement of the second objective. Methods of determining magnitude and incorporating environmental quality objectives into evaluation procedures were summarized in the development of a seven-step model in Chapter IV for use in evaluating amenity values at reservoir sites. The seven basic steps in the methodological framework were: (1) problem delimitation, (2) estimation of net monetary benefits from reservoir construction to measure contribution to economic development of the proposed projects, (3) determination of the physical magnitude of reservoirs upon natural resources which might provide amenity services, (4) determination of the relative magnitude of alternative resource classes in providing amenity services (importance), which when combined with (3) can provide an aggregate index of the effect upon environmental quality by the economic development alternative under consideration, (5) identification of a trade-off curve using net benefits from reservoir construction on one axis to represent economic development, and an aggregate index



measure of environmental quality on the other axis, (6) monetary measurement of amenity services by a willingness-to-pay model applied to a green-belt recreation and preservation area which would occupy the site otherwise to be inundated by a reservoir, to allow application of the maximum GNP criterion by benefit-cost analysis of alternative development proposals, and, (7) Pareto-betterment if a trade-off or production-possibility curve was identified in Step (5) which did not represent the frontier because of institutional or other restraints. Pareto-betterment referred to movement from within the production space to a point on the frontier, preferred because more output is technologically possible to achieve by removing restraints, and more is assumed preferred to less.

The fourth objective was to apply and test this framework in the Ames Reservoir, planned for the Skunk River by the U.S. Army Corps of Engineers, and to be located just north of Ames, Iowa. This project would affect about 5,200 acres of land in achieving objectives of flood control, waterbased outdoor recreation, and enhanced downstream water quality. Monetary net benefits were available from benefit-cost estimates prepared by the Corps of Engineers. However, during the process of this present study, and described in Chapter VI, the Ames Reservoir Environmental Study group at Iowa State University and the University of Iowa questioned the analysis by the Corps of Engineers on a technical and conceptual basis, leaving net benefits from the Ames Reservoir

in doubt at present. Physical magnitude of the Ames Reservoir was also identified by the same interuniversity study group and made available for use in this study. Steps (2) and (3) were therefore accomplished by the work of others.

Application of Steps (4), (5), and (6) became the major empirical requirements of the methodological framework for which convenient data did not exist. A public survey was deemed necessary to obtain information which could be used to obtain an aggregative index of environmental quality for one axis of a production-possibility curve. The survey would also obtain measures of monetary amenity benefits from the green-belt park system using a willingness-to-pay model as described in Chapter III, to apply the maximum GNP criterion.

Subsequently, a questionnaire was prepared which would obtain the required data from a random survey of the public in the "zone of influence" for the Ames Reservoir. The questionnaire was employed in 294 personal interviews in about a 60 mile radius from the center of the proposed green-belt area. Numerical results of the survey were presented in Chapter VI. Highlights of the numerical results are now summarized.

An aggregated index level of amenity values, used as a measure of environmental quality, was obtained from public responses to statements concerning importance of preservation for seven selected resource categories. Responses could take eleven values, from strongly disagree to strongly agree that preservation of a

certain natural resource was important to their household. After a mathematical transformation, described in Chapter VI, arithmetic means of responses were used to determine an index of relative importance for each resource category, on a 10 point scale where 0 represented minimal importance and 10 represented very strong importance.

Wildlife was shown to be the most important resource category, with an index value of 8 on the 10 point scale. Forest was shown to have a value of 7. Prairie potholes were least important, with an index value of 3 by this method of measurement. Table 6-3 presents the index values for the remaining categories. These index values were obtained for two reservoir projects--the Corps of Engineers multiple-purpose reservoir project which would affect about 5,200 acres of land, and a smaller 1400 acre recreation lake. The individual index values were then multiplied with the index of magnitude of physical impact, Table 5-1, to obtain an aggregated index of amenity values affected by each project.

Comparison of aggregated index values, Table 6-3, showed that the recreational lake would have about only 27 percent of the environmental impact, in terms of lost amenity services, when compared with the Corps of Engineers multiple-purpose project. A trade-off curve could now be developed between environmental quality and monetary net benefits from economic development at the reservoir site by reservoir construction. However, since net benefits for both projects appeared at present to be negative,

no trade-offs existed as these projects did not seem at present to be economically justified. Hence Step (7) of the methodological framework, Pareto-betterment, was not applied as no trade-off curve existed with positive contributions to economic development on the development axis.

In deriving the individual index values for each category, wildlife and forest were shown to be two resource categories in the potential region of inundation for which the public felt strong agreement that preservation was important. When questioned as to reasons for feeling that preservation was important, there was unanimous agreement by the public that viewing of wildlife was enjoyed. Forest was appreciated because forest provided an area of natural beauty and pleasure, as well as providing an area for outdoor recreation. Table 6-2 summarizes public responses to possible reasons for feeling that preservation was important.

Regression analysis was employed to determine household characteristics that were related to responses to the statements regarding importance of preservation. Generally, related variables identified explained only a very small portion of the variation in statement responses. Larger households and rural addresses were most frequently related, always negatively, showing generally less feeling for importance of preservation.

An alternative technique for ranking resource categories was also employed, by allocating 100 points between the seven selected resource categories, in order to obtain additional information

which could be used to choose the most preferred resource categories. Using all the information obtained on the survey, it was determined that wildlife was the most important category in providing amenity values, forest was second most important, and the free-flowing stream (the Skunk River), wooded parks and wooded pasture were about equally placed in third place. Remnants of Iowa prairie were in fourth with prairie potholes least important, in fifth place, of the seven selected resource categories considered.

In applying the willingness-to-pay model to employ the maximum GNP criterion, respondents were requested to state willingness to visit a green-belt park system which would preserve the resources in the region of the proposed Ames Reservoir. When extrapolated from the sample to the population, total willingness to visit was estimated to be about 2.8 million visitors per year. This was felt to be a gross overestimate of actual visitation if the green-belt were constructed, but indicated potential popularity of the project. Reasons that might account for overestimation included undue optimism on the part of the respondent, overstating potential visits to ensure its construction, and the small size of sample since a few responses could account for a great deal of the visitation.

A total willingness to spend of about 4 million dollars per year was estimated from the population in the 9 county survey area. This value can be considered a maximum amount of monetary benefits that may be attributed to the green-belt area; as respondents were

requested to state maximum willingness to spend, values that they might never need to pay if access is cheaper or the green-belt is financed otherwise. It was shown in Chapter VI under the specific assumption of a near zero discount rate, to account for future time preference of the public consumption of amenities, that initial yearly benefits needed only equal about 90,000 dollars to obtain a benefit-cost ratio of unity, assuming a planning horizon of 50 years. Hence, the green-belt area was felt to be a feasible investment project in terms of the maximum GNP criterion.

Regression analysis was used to obtain prediction equations for estimating visitation and willingness to spend. These are summarized in Table 6-12. Age of head and distance were negatively related to visitation, while household size and households with a craftsman as head were positively related. The fit of the prediction equation was considerably higher than previous equations, accounting for more of the variation in visitation responses. In regards to willingness to spend, only age of the household head and distance to the green-belt were related, both negatively. Income did not affect monetary responses, indicating that household income does not influence expenditures for the green-belt system, an unexpected result.

Respondents were also requested to rank the four development alternatives of the green-belt area, the multiple-purpose reservoir project as proposed by the Corps of Engineers, a 1400 acre recreational lake, and leave the area in private control. Results are

summarized in Table 7-13. The green-belt was most popular, followed by leaving the area in private control, the recreational lake, and the multiple-purpose reservoir, in that order. This provided additional support for the potential feasibility of the green-belt recreation and preservation area.

The fifth study objective was to suggest further research needs in the analysis and achievement of environmental quality objectives. Such research needs emanated from the limitations of the study as well as conclusions made during the study process. Recommendations for future research are presented in a later section of this chapter.

#### Limitations of Study

Application and testing of the methodological framework created to identify, measure, and incorporate environmental quality objectives in the development of natural resources indicated limitations of the study. The major limitations are summarized as follows:

1. Only seven natural resource categories were chosen to be included in the survey. Additional categories are likely to provide amenity services, such as strings of trees along smaller watercourses and archaeological sites.
2. The effect of the multiple-purpose reservoir was described on the survey questionnaire as "destroying or affecting" acreages of resource categories. This was never precisely defined.

3. Persons under 18 years of age were not interviewed.

The possibility exists that the opinions of children in a household were not represented. Likewise, it was assumed that the respondent represented the entire household, instead of just himself or herself.

4. The extent of biases in the questionnaire could not be determined. It was felt that biases were built into the survey encouraging respondents to state that preservation of the natural resources was important. On the other hand, demand for preservation of the natural resources may be very strong.
5. Visitation and willingness to spend estimates concerning the green-belt area were likely to be overestimated to such an extent that the absolute values were meaningless. An added factor is that sample size may have been inadequate. Alternative methods of measuring benefits were not employed as checks, such as the use of sophisticated gravity models used by Cesario (17).
6. It was assumed that the green-belt park and preservation area would protect and preserve natural resources at the Ames Reservoir site. This may not be the case as overuse can also result in destruction.
7. Only negative impacts upon the natural resources were discussed. No mention was made of positive impacts of the two reservoirs upon amenity values. For example, a



recreational lake would provide a scenic view from the nearby interstate highway.

8. Institutional rigidities were not discussed. It was assumed that construction of the green-belt area was institutionally feasible.
9. Development alternatives of the Skunk River valley between Ames and Story City were not explored. The possibility exists that residential development of the valley would provide much satisfaction to the residents, values which would be precluded if a green-belt area or reservoir were developed.
10. The recreational lake was not given adequate consideration in terms of its economic feasibility. Conclusions of the Ames Reservoir Environmental Study in regards to the recreational lake were accepted without question.

### Conclusions

The general purpose of this study was to seek the nature of trade-offs between environmental quality and economic development, focusing on the effect of water resource development upon the supply of amenity services from natural resources. A specific problem area in Central Iowa, the proposed Ames Reservoir, was used to study the feasibility of applying a methodological framework that would incorporate often-times conflicting social objectives of economic development and environmental quality in meeting criteria of economic performance.

Three conclusions were made regarding the results of this study. The first conclusion was that the methodological framework developed in this study was useful to incorporate environmental quality into the evaluation of natural resource development alternatives. The framework employs two criteria for economic performance which are the broad productivity criterion and the maximum GNP criterion. The framework is designed specifically for the case of reservoir construction in Iowa where a river reach and valley is altered by construction of a dam and reservoir in the river valley. The framework can readily be adapted to reservoir planning situations in other areas.

The basic method employed was to first identify and measure the effect upon amenity services in the regions to be affected by natural resource development projects. A trade-off curve was obtained which identified trade-offs between environmental quality and natural resource development. This curve cannot be considered the production-possibility frontier since the development axis considers only those alternatives possible under the existing institutional framework. Once such a curve has been achieved, alternative methods of achieving the development objectives can be sought in order to achieve a Pareto-better redistribution of the social outputs of development and environmental quality, to apply the broad productivity criterion.

If the production frontier has been identified, along with society's present position, the problem remains of determining

the "best" point on the frontier. In lieu of a social welfare function and supply and demand prices for all outputs the remaining alternative is use of the opportunity cost concept.

Even if the frontier cannot be reached because of institutional restraints, it is still useful to obtain some absolute measure of the environmental quality benefits in monetary terms. Such a measure will provide a common base to aid in the comparison of alternative points in the feasible region (production space) by use of the maximum GNP criterion. Net benefits from environmental quality can be compared with net monetary benefits from development as exemplified by the Ames reservoir to determine the alternative which will contribute most to economic development. A willingness-to-pay method based on interview techniques provides a monetary measure of amenity benefit from both active and passive enjoyment of natural resources under consideration.

Further conclusions emanate from the specific application of the framework to the problem posed by the Ames Reservoir. Hence, in obtaining information for use in measuring the level of amenity services, it was concluded that wildlife was the resource category preferred most by the public for preservation because of contribution to amenity values, followed in second place by forest. The Skunk River (at the reservoir site), existing wooded parks, and wooded pasture were all closely ranked in third place, prairie relics were in fourth place, and prairie potholes were in fifth place of the seven resource categories chosen for specific

consideration.

A third conclusion resulting from this study is that the green-belt area proposed for preserving the above resources is a resource development alternative that should be considered for establishment before any large reservoir is constructed. The basis for this conclusion is the general public response that preservation of natural resources is strongly to moderately important, the willingness of the public to state that they will visit the green-belt area and financially aid in its construction leading to positive benefit-cost ratios, and the first place ranking of the green-belt area by the public over alternative modes of development.

Finally, the analysis in this study suggests that:

1. the natural resources at the Ames Reservoir site provide beauty and pleasure that is appreciated by the public,
2. citizen participation is important in planning the development of natural resources in which citizens are directly involved,
3. public agencies cannot assume that the value of land is equal to the market price per acre, based solely upon the capitalized value of future agricultural returns. Additional values, not reflected in the marketplace, are those resulting from consumption of amenity services flowing from the environment.

### Recommendations for Further Research

The conceptual discussion and empirical application of the methodological framework developed in this study have provided directives for further research in the field of environmental quality. Further research is now apparent in the following general areas:

1. Multiple-discount rates for discounting different types of outputs need to be examined in more detail, to determine applicable rates depending on the relevancy of social opportunity cost of capital or social time preference to the output under consideration.
2. Research is needed to identify natural resource categories at other development sites which are likely to provide amenity services, and measurement of the extent of these amenity services.
3. Study is needed of benefit-cost procedures as used by public agencies to ensure conceptual validity of techniques employed. Improper use of benefit-cost analysis, as suggested in Chapters III and IV of this study, can justify uneconomical development alternatives that may significantly affect environmental quality. Included is an ex-post analysis of completed projects to determine if benefits have materialized as predicted.
4. A related research need to analysis of benefit-cost procedures is to study means of reducing institutional

rigidities which prevent society from operating near or upon the production-possibility frontier. All production opportunities need to be considered.

5. With respect to the questionnaire employed in this study, research is needed to identify and reduce biases that may or may not be present.
6. Alternative techniques need to be explored, such as simple or sophisticated gravity models and indifference curve mapping (75), to estimate potential green-belt visitation levels more accurately than was done in this study by willingness-to-pay models. However, values of non-users may not be considered.
7. Research is needed to more fully analyze the possibility of a recreation reservoir near Ames which would supplement a green-belt area by providing facilities for those who prefer water based outdoor recreation.
8. Inventories of natural resources that will be affected by natural resource development need to be obtained, aiding in evaluation of development alternatives.
9. Reasons need to be obtained why larger households tend to have a negative attitude toward the importance of preservation of natural resources.
10. This study did not address the problem of determining effects that the green-belt park system would have upon other parks in the region, including those in the City of Ames. The

possibility exists that the green-belt would attract users from existing park facilities so that investments in existing parks may not be utilized as planned. Research is therefore required to determine impacts of the green-belt upon present park facilities. Included is study of alternative planning possibilities for the green-belt which would minimize effects upon local parks by providing recreation facilities not obtained in the city and town parks while preserving natural resources at the Ames Reservoir site.

11. Research is required to determine shifts in GNP resulting from construction of the green-belt park system. For example, if the green-belt shifts consumption from privately provided recreational facilities to the public facility of the green-belt, there will be changes in components of GNP that will affect income distribution. Entrepreneurs must now face additional competition from public enterprise. However, gains to the consumers of non-marketed amenity services provided by the green-belt must be compared to the loss of income to private enterprise. Included in a consideration of determining shifts in GNP is the effect of green-belt construction upon the regional economy through accelerator and multiplier effects which will vary depending upon the level of unemployed labor and capital resources in the relevant region of consideration.

12. The economic performance criterion of equity was not considered in this study. Resource development which favors preservation and enhancement of amenity values over values resulting from market allocated goods and services will tend to redistribute real income and utility to those social members who obtain satisfaction from consumption of amenity services. Hence, redistributational implications of furtherance of the environmental quality objective are likely to occur and need to be noted. Likewise, construction of the Ames Reservoir as proposed by the Corps of Engineers will likely redistribute real income away from those who must sacrifice amenity values at the reservoir site to those who receive project benefits such as improved flood control. Hence, research is needed to determine distributional effects of natural resource development alternatives if a more equitable distribution of social output is desired as a goal of society.



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APPENDIX A: THE SURVEY QUESTIONNAIRE

Central Iowa Environmental Study

Head of household \_\_\_\_\_ Interviewer \_\_\_\_\_

Address \_\_\_\_\_ Seg. No. \_\_\_\_ Household No. \_\_\_\_

Town \_\_\_\_\_

Telephone No. \_\_\_\_\_ Date \_\_\_\_\_ Time \_\_\_\_\_  
(area)

Name of respondent \_\_\_\_\_ 1st call \_\_\_\_\_

Starting time \_\_\_\_\_ 2nd call \_\_\_\_\_

3rd call \_\_\_\_\_

at Ames. You may know that the Army Corps of Engineers is considering building a reservoir on the Skunk River. The University is interviewing persons who live in central Iowa in order to make estimates of the kinds of values that people place upon natural resources that would be flooded by construction of the proposed Ames Reservoir. The study will make possible a better comparison of all the money and non-money benefits and costs of the proposed lake. The information is important in the planning of such facilities as parks and recreational areas.

First, could we have the name of the head of the household, and spouse, if any.

Section I

Are there any other members living in this household? \_\_\_\_ Yes \_\_\_\_ No

If YES, What are their names, starting with the oldest?  
(Complete Cols. a thru g for ALL members of the household)

(a) How is \_\_\_\_\_ related to the head of the household?

(b) Male or female?

(c) How old was (he)(she) on (his)(her) last birthday?

(d) How many years of schooling has (he)(she) completed?

(e) How many years has \_\_\_\_\_ lived at this address?

(f) How many years has \_\_\_\_\_ been a resident of Iowa?

[For members 18 and over:]

(g) What is \_\_\_\_\_'s occupation--what kind of work does  
(he)(she) do?

	(a)	(b)	(c)	(d)	(e)	(f)	(g)
	Rel.			Grade	Years	Years	
	to				lived	Iowa	
Name	head	Sex	Age	comp.	here	resident	*Occupation
1.	Head						
2.							
3.							
4.							
5.							
6.							
7.							
8.							
9.							
10.							

\*If retired, please note previous occupation.

## Section II

### INTRODUCTION

You are probably aware that the Army Corps of Engineers has proposed the building of the Skunk River Reservoir just north of Ames. This map shows the region that is being studied in connection with this Reservoir. The Reservoir would:

- (1) store water for flood control
- (2) store water for release during drought to maintain low flow
- (3) store water for recreation.

The permanent lake would cover about 2,100 acres. An additional 3,000 acres would be reserved for flood storage. In total, the project would affect about 5,100 acres of land. For comparison purposes only, an alternative to this project would be a 1,400 acre lake for recreational purposes. The study region, as shown on this map, is comprised of 34 sections, each section containing some part of the reservoir. It is located entirely within Story County.<sup>1</sup>

#### I. WOODED PARKS

There are about 70 acres of wooded county and town parks in the study region, including McFarland Park near Ames and Morland Park of Story City.

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<sup>1</sup>The data in the questionnaire was obtained from draft chapters of the Ames Reservoir Environmental Study (80, 81, 86).



- A. Multi-purpose project (the reference we will use from now on for the large reservoir)

The multi-purpose reservoir would flood about 1/2 of these wooded parks. As I read statements from time to time, would you tell me first if you AGREE or DISAGREE with the statement, and then how strongly you agree or disagree, as shown on the card.

Statement 1. Preservation of these existing parks is important to me and my family. Do you agree or disagree with this statement? How strongly?

Agree

1      2      3      4      5

Disagree

- B. Recreational Lake (The term we will use for the alternative smaller lake.)

None of these wooded parks would be directly affected by flooding.

## II. PRAIRIE RELICS

In the study area there still exists about 25 acres of dry Iowa prairie in its native state. There also exists about 45 acres of moister native prairie, found in moderately wet areas. Very few acres of significant size of the dry and wetter prairie remain in central Iowa. They offer a hint of pre-settlement Iowa. The wetter prairie, especially, is kept colorful by prairie wildflowers.

- A. Multi-purpose project

About 7 of the 25 acres of dry prairie and 10 of the 45 acres of moister prairie would be destroyed. There would be damage to additional dry acres.

Statement 2. The preservation of these existing acres of dry and wet prairie is important to me and my family.

Agree

1      2      3      4      5

Disagree

B. Recreational Lake

The result of this flooding would be insignificant.

III. PRAIRIE POTHOLES (Prairie potholes are small, wet, poorly drained areas that usually dry out every year.)

About 27 acres of land containing prairie potholes remain in the region, consisting mainly of 4 potholes of varying depth. They make excellent scientific study sites for the study of plants and their relationship to water. These potholes remain a remnant of Iowa's past.

A. Multi-purpose project

About 11 of these 27 acres of land containing potholes would be destroyed.

Statement 3. Preservation of this pothole acreage is important to us.

Agree

1      2      3      4      5

Disagree

B. Recreational Lake

This smaller project would flood about 5 acres of these prairie potholes.

Statement 4. Preservation of this pothole acreage is important to me and my family.

Agree

1      2      3      4      5

Disagree

[Interviewer: If respondent disagrees with all three of statements 2, 3 and 4, skip to Part IV, Forest.]

We have several reasons given here that may describe why you feel this way about prairie potholes and relics. Would you please tell me whether you agree or disagree with these statements and how strongly you feel, as we did before.

Reason 1: We enjoy the existence in central Iowa of some natural unforested landscape which has not been changed by man's activities.

Agree

1 2 3 4 5

Disagree

Reason 2: Valuable scientific study sites that are close to Iowa State University will be lost.

Agree

1 2 3 4 5

Disagree

Reason 3: These sites represent a valuable heritage because because they are a remnant of Iowa's past landscape.

Agree

1 2 3 4 5

Disagree

Reason 4: We would like to preserve plants and flowers of the native prairie and pothole acreage because of their diversity, beauty and virgin character.

Agree

1 2 3 4 5

Disagree

Reason 5: Potholes are important in providing waterfowl habitat for hunting, viewing and study purposes.

Agree

1 2 3 4 5

Disagree

IV. FOREST (By this we mean where at least 1/4 of the ground is roofed by leaf cover.)

In the study region, there are about 2,000 acres of forest. About 1,100 acres of this is upland forest. Of the upland forest, about 3/4 is oak-hickory forest with the remainder elm-ash and maple-basswood forest. The rest is lowland forest, located on the land now subject to natural river flooding and containing a wide diversity of tree species. These forests appear to be very representative of central Iowa. Except for the oak-hickory, much of which is pastured, most is in its original state. This forest provides excellent habitat for wildlife.

A. Multi-purpose project

This reservoir would destroy or seriously modify about 600 acres of the upland forest. About 700 acres of the lowland forest will be destroyed.

Statement 5. Preservation of these 1,300 acres of the 2,000 total of forest is important to us. Do you agree or disagree with that statement? And how strongly?

Agree

1      2      3      4      5

Disagree

B. Recreational Lake

As mentioned earlier, an alternative to the multi-purpose project would be the 1,400 acre lake for recreational purposes. If this lake were built, it would destroy or seriously modify about 135 acres of the upland forest and about 375 acres of the lowland forest.

Statement 6. Preservation of these 500 acres of forest is important to us. Do you agree or disagree? And how strongly?

Agree

1      2      3      4      5

Disagree

[Interviewer: If respondent disagrees with both statements 5 and 6, skip to Part V, Wooded Pasture.]

We have several reasons listed that may describe why you feel this way. Tell me, please, if you agree or disagree.

Reason 1: Preservation of the forest will provide a contact with nature that is relatively devoid of man's influence.

Agree

1 2 3 4 5

Disagree

Reason 2: By preservation of this forest, a heritage will be provided to future generations.

Agree

1 2 3 4 5

Disagree

Reason 3: The forest provides an area of natural beauty and pleasure that can be enjoyed in the same manner as other forms of beauty.

Agree

1 2 3 4 5

Disagree

Reason 4: Preservation of the forest will allow the possibility of providing outdoor recreation in such forms as hiking and nature trails, camping, picnicking, etc.

Agree

1 2 3 4 5

Disagree

## V. WOODED PASTURE

There are about 900 acres of wooded pasture in the study region. About 2/3 of this wooded pasture is dominated by large trees, the rest has small trees and shrubs.

A. Multi-purpose project

About 1/2 of this wooded pasture would be destroyed or seriously modified.

Statement 7. The preservation of this wooded pasture is important to us because of the loss of trees and shrubs.

Agree

1      2      3      4      5

Disagree

B. Recreational Lake

About 135 acres of this wooded pasture would be destroyed or seriously damaged.

Statement 8. The preservation of this wooded pasture is important to me and my family because of the loss of trees and shrubs.

Agree

1      2      3      4      5

Disagree

VI. WILDLIFE

In the region studied, the entire area shown on the map, about 3,750 acres of the land, is suitable in varying degrees for wildlife. In 1972, at least 30 species of birds were identified in the region and at least 24 species of animals.

A. Multi-purpose project

Since 2,100 acres would be flooded by the permanent pool, most of the wildlife in this region would be lost. These displaced birds and animals would not be expected to survive because of competition for habitat. In the remaining 3,000 acres which would be occasionally flooded, changes in vegetation would create severe species and population changes.

Statement 9. Preservation of this wildlife is important to me and my family

Agree

1      2      3      4      5

Disagree

B. Recreational Lake

It is expected that much of the wildlife in the 1,400 acres of land that would be flooded would be lost.

Statement 10. Preservation of this wildlife is important to us.

Agree

1 2 3 4 5

Disagree

[Interviewer: If respondent disagrees with both statements 9 and 10, skip to Part VII, Free-Flowing Streams.]

Please consider the following as possible reasons for your feeling this way.

Reason 1: The wildlife in this area is unique, rare and valuable as a heritage from Iowa's past.

Agree

1 2 3 4 5

Disagree

Reason 2: We need to preserve this wildlife so that future generations can also enjoy them in their natural surroundings.

Agree

1 2 3 4 5

Disagree

Reason 3: We enjoy the presence and existence of wildlife in the region even though we may not go to the area to see them.

Agree

1 2 3 4 5

Disagree

Reason 4: We enjoy viewing wildlife in their native habitat.

Agree

1 2 3 4 5

Disagree

## VII. FREE-FLOWING STREAMS

North of Ames, the Skunk River is a meandering, narrow stream. Wooded areas are on both sides for most of the distance to Story City. The stream contains numerous pools and shallow areas. Smallmouth bass and channel catfish are popular in the region at present for sports fishing. This portion of the river is still in a very natural state.

In contrast, the river south of Ames has been straightened by man (early 1900's), resulting in a broad, shallow, slow-flowing sand bottomed stream. Except for a few wooded plots near Ames, there is essentially no wooded area for at least a thirty mile stretch south along the stream.

### A. Multi-purpose project

The character of the stream north of Ames would be changed from the damsite to Story City, about 10 river miles. Although the Des Moines River and Ledges State Park, about 13 miles west of Ames, are nearby they will be affected by the Saylorville dam and reservoir, presently under construction. The nearest streams, similar in character, are on the Boone River, about 25 miles northwest of Ames and the Iowa River, about 35 miles northeast of Ames.

Statement 11. Preservation of this free flowing stream is important to me and my family.

Agree

1      2      3      4      5

Disagree

[Interviewer: If respondent disagrees with statement 11, skip to Section III.]



The following may constitute possible reasons for your feeling this way:

Reason 1: The stream is unique in its natural and scenic setting, and needs to be preserved.

Agree

1 2 3 4 5

Disagree

Reason 1: We enjoy, or might enjoy, the use of the stream and surrounding area for recreation, such as hiking, canoeing, or fishing.

Agree

1 2 3 4 5

Disagree

Reason 3: The Skunk River is a heritage of Iowa's past since it is still in its natural state.

Agree

1 2 3 4 5

Disagree

Reason 4: The stream and the trees, vegetation, wildlife, etc. should be preserved in their entirety.

Agree

1 2 3 4 5

Disagree

Section III

8. Regardless of your feelings about the proposed reservoir or the recreational lake, if your family were given \$100 to spend on these 7 categories we have just talked about, how much of the \$100 would you spend on each one? How much would you spend on parks? prairie relics? potholes? forest? etc. (until respondent has "spent" the entire \$100).

Wooded parks	\$ _____
Prairie relics	_____
Prairie potholes	_____
Forest	_____
Wooded pasture	_____
Wildlife	_____
Free-flowing streams	_____
Total	\$ 100.00

Section IV

9. Suppose that about 1/2 of the forested land and virgin areas between Ames and Story City were purchased by the public and developed into a "green-belt" area. For our purposes, we will say that a "green-belt" area is a recreation and preservation area with a natural stream as the center of attraction, in which facilities have been provided such as trails, picnic sites, camping areas and parking.

(a) Tell me about how many days a year you think you and other members of your family would visit such a site. Would you say:

Days per year	Family member number(s)
1-2	seldom
3-5	a few times
6-10	several
11-15	frequently
16 +	great deal
0	none

[Interviewer: If every family member responds "none," ask (b) and then skip to (d).]

(b) Why do you think this household would not visit the area?

- \_\_\_\_\_ too far
- \_\_\_\_\_ prefer a lake
- \_\_\_\_\_ not enough time
- \_\_\_\_\_ very little participation in outdoor recreation
- \_\_\_\_\_ other (explain) \_\_\_\_\_

(c) In what recreational activities would you or members of your family probably participate in at such an area? (Read each and check one or more.)

Yes    No

_____	_____	picnicking
_____	_____	driving for pleasure
_____	_____	fishing
_____	_____	hiking
_____	_____	biking
_____	_____	observing wildlife
_____	_____	camping
_____	_____	canoeing
_____	_____	mushroom hunting
_____	_____	sledding
_____	_____	ice skating
_____	_____	skiing (snow)
_____	_____	other (specify) _____

(d) Even though this "green-belt" area might receive state or federal aid, it may be necessary to provide additional financial support. What is the most money, if any, that you and your family would be willing to spend per year to visit the area or to aid in its establishment?

\$\_\_\_\_\_ per year

[If zero dollars] Why do you feel this way?

[Interviewer: Do not read.]

- ☐ cannot afford it
- ☐ other recreation areas are available
- ☐ this area is not worth spending money on
- ☐ should not have to pay to visit outdoor recreation areas
- ☐ other (specify) \_\_\_\_\_

10. This card has a wide range of income categories. Would you please tell me which category best represents the total income of the members of this family for the year 1972. Please include all the income of every member including wages, interest, dividends, public assistance, unemployment compensation, net income from business, etc., before taxes.

- ☐ Under \$3,000
- ☐ \$ 3,000 to \$5,999
- ☐ \$ 6,000 to \$9,999
- ☐ \$10,000 to \$14,999
- ☐ \$15,000 to \$24,999
- ☐ \$25,000 and over

11. Now, considering all the things we have talked about, such as the loss of natural resources, the possibility of improved recreational facilities, and so on, would you tell me which of these four choices you prefer first, second and third.

- ☐ 1. The green-belt area (which preserves the stream and natural surroundings)
- ☐ 2. The 1,400 acre recreation lake
- ☐ 3. The multi-purpose project (the larger project proposed by the Army Corps of Engineers)
- ☐ 4. Leave the area in its present state of private control.

12. Have you (the respondent) spent one-half or more of your life in any of the following categories:

- ☐ Farm(s)
- ☐ Rural nonfarm
- ☐ City (cities) under 10,000
- ☐ City (cities) over 10,000
- ☐ None of the above

We want to thank you so much for your cooperation and interest in this project.

\_\_\_\_\_ ending  
time

APPENDIX B: ADDITIONAL INFORMATION  
REGARDING RESOURCE CATEGORIES

This appendix provides additional information to that which was provided on the questionnaire for the resource categories of prairie potholes, forest, wooded pasture, wildlife, and the free-flowing stream. References to study region, samples, etc. in this appendix refer always to ARES, from which the material was gleaned (80, 81, 86).

### Prairie Potholes

Before Iowa was developed for agriculture, about one-half of the Iowa prairie in central Iowa was pockmarked by these wet depressions in the landscape. At the center of a deeper pothole, the water may remain all year. A wide variety of plant species can be found in these prairie potholes.

### Forest

In the study region, which is located entirely in Story County, there are about 2020 acres of forest. Of this forest, about 1090 acres are in upland forest and 930 acres are in lowland or floodplain forest.

Of the upland forest, about 790 acres is oak-hickory forest. Much of this is grazed. Another 150 acres is elm-ash forest, with much of the elm dying because of Dutch Elm disease. An additional 150 acres is maple-basswood forest. Both the elm-ash forest, and the maple-basswood forest appear to be in a relatively virgin state.

Of the lowland forest, or mixed flood plain forest, most tends to reflect the original floodplain forest. The wide diversity of



tree species includes willow, cottonwood, river birch, sycamore, maple, elm, basswood, ash, hackberry, black walnut, butternut and yellowbud hickory.

The timber in these forests appear to have no significant value for lumber purposes. They seem to be representative of Central Iowa. The forest will have fair to good potential of self-reproduction, with the provision of adequate cultural practices such as limited grazing. The forest provides excellent habitat for wildlife.

#### Multi-purpose reservoir

This reservoir, as planned by the Corps of Engineers, would destroy or seriously modify about 610 acres of the upland forest, or about two-thirds of the 1090 acres in the study region. Of this forest, about 415 acres of the oak-hickory forest will be affected. In addition, about 90 acres of the elm-ash forest and about 105 acres of the maple-basswood forest will be affected.

Of the lowland or floodplain forest, about 685 acres or about three-quarters will be destroyed by flooding.

#### Recreational Lake

This lake, if built, would destroy or seriously modify about 135 acres of the upland forest. Of this about 85 acres of the oak-hickory forest would be affected. Approximately 25 acres of the elm-ash forest, and also about 25 acres of the maple-basswood forest will be affected.

Of the lowland or floodplain forest, about 370 acres will be destroyed by flooding.

#### Wooded Pasture

There are about 890 acres of wooded pasture in the study area. This is grazed or pastured land containing scattered trees. Scattered large trees such as found in both the upland and floodplain forests dominate about 585 acres. Another 235 acres of this wooded pasture is dominated by trees of juniper and honeylocust species. An additional 70 acres are dominated by various kinds of shrubs such as sumac, hawthorn, prairie crabapple, prickly ash, gooseberry, raspberry, multiflora rose and chokecherry.

#### Multi-purpose reservoir

About 320 acres of the pasture containing scattered large trees would be affected. An additional 105 acres of the wooded pasture dominated by juniper and honeylocust would be destroyed. Approximately 50 acres of the pasture with shrubs would be flooded.

#### Recreational Lake

This lake would flood about 110 acres of the pasture containing scattered large trees. About 15 acres of the wooded pasture dominated by juniper and honeylocust would be destroyed. Approximately 10 acres of the pasture with shrubs would be affected.

## Wildlife

### Habitat

After excluding farm buildings and yards, urban areas (mainly at Story City, including golf courses and cemetery), quarry sites, roadsides, open pasture and all cultivated land, about 3760 acres of land remain in the study region which is suitable in varying degrees for wildlife.<sup>1</sup> This was subdivided into the categories and acreages as listed in Table 1. Included is the effect of each project upon each type of habitat.

Habitat quality for wildlife in this region varies from poor to excellent depending upon the type of wildlife, proximity to developed areas, size of tract, and so on. Pheasant, of course, is commonly found in cultivated fields. In the study region, there are about 14,400 acres of cultivated farm land. The multi-purpose project will flood about 2210 acres of this and about another 560 acres of open pasture.

### Birds

In 1972, at least 30 species of birds were identified in the region. Some species such as hawks, doves, woodpeckers, swallows, jays, nuthatches, grackles, and blackbirds were relatively abundant in terms of ideal population densities. There was a fair abundance of woodduck, pheasant, flycatchers, titmice, starlings,

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<sup>1</sup>This section on wildlife habitat was the interpretation of this researcher.

Table B-1. Acres of wildlife habitat

Type of habitat	Acres in study area	Acres affected by multi-purpose project	Acres affected by recreational project
Forest	2015	1300	510
Wooded pasture	890	475	135
Strings of trees along watercourses	400	240	78
Assorted tree plantings including windbreaks	90	15	0
Wooded edge and transitional	40	25	8
Wooded parks	70	35	0
Fence rows	105	31	8
Non forested virgin prairie, march, and potholes	105	33	16
Existing ponds and reservoirs	45	18	19
Total	3760	2172	775

warblers, house sparrows and cowbirds. Other species that were yet less common included herons, owls, swifts, kingfishers, wrens, orange winged warblers, waxwings and sparrows. Finally, waterfowl (excluding herons and the woodduck), quail, rails, larks, thrashers and vireos were identified but population levels were very low. This could be due to unsatisfactory habitat, and an inadequate time period for sampling.

### Animals

There were at least 24 species of animals identified in the region in 1972. Animals in relative abundance included fox squirrels, raccoons, and insectivores. There was a fair abundance of cottontail rabbit, woodchuck, cricetidae, striped skunk, and whitetailed deer. Other species that were yet less common included opossum, beaver, muskrat, red fox, mink and weasels. Finally, very low population levels were identified for jack rabbits, chipmunks, 3 other types of squirrels, pocket gophers, coyotes, badgers and spotted skunks. Again, this could be due to unsuitable habitat plus inadequate animal surveying times.

In addition, toads, frogs, turtles, lizards and snakes were identified, but in general, populations ranged from very low to poor for these species, at least in the period of sample.

### Multi-purpose reservoir

Since 2100 acres will be flooded by the permanent pool, all terrestrial wildlife in this area will be lost. All birds except waterfowl will also be lost. Wildlife in this area of 2100 acres will not be able to move into and successfully occupy other similar habitat because of competition from established resident wildlife species. There is simply not enough available habitat in the region to accommodate the displaced animals and birds. Most of the area in the permanent pool is above average quality habitat for Central Iowa.

In the remaining 3,000 acres in the flood pool which will be occasionally flooded, there will be severe species and population changes from the present situation. This is due to changes in the vegetation caused by infrequent flooding which will not allow permanent establishment of many desired plants for wildlife purposes. There will be loss of highly diverse vegetation which can support a high density of birds, even in winter. Finally, increased development around the reservoir for such purposes as recreation and housing may eliminate much wildlife that could ordinarily survive the reservoir alone.

#### Recreational reservoir

It is expected that most of the wildlife in the 1400 acres of land that will be flooded would be lost. Wildlife will not be able to move into and successfully occupy the remaining habitat because of competition from existing species. Competition, however, should be less intense so that there might be a higher survival rate. Increased development and activity around a recreation reservoir will also adversely affect wildlife by destroying additional habitat.

#### Free-Flowing Stream

For the purpose of stream fish, the diversity of stream habitat in the Skunk River north of Ames is better for fish populations than the Skunk River south of Ames. There are numerous pools in the stream north of Ames that serve as survival areas

during dry seasons. Recent surveys resulted in the identification of at least 34 species of fish in the river north of Ames, including the headwaters and tributaries.

On the other hand, recent surveys found only 24 species of fish in the Skunk River south of Ames. There were few species other than minnows and shiners.

APPENDIX C: SAMPLE SELECTION AND USE



### Sample Description<sup>1</sup>

The universe for this study consisted of all households in a 9-county area of central Iowa; specifically, the counties were Boone, Dallas, Hamilton, Hardin, Jasper, Marshall, Polk, Story, and Webster.

Two geographic strata were defined--an inner stratum centered around the proposed Ames Reservoir and an outer stratum consisting of the remaining area. The inner stratum consisted of all of Story County, the southwest corner of Hardin County, southern Hamilton County and eastern Boone County. Within each stratum, six substrata were identified based on size of community according to the 1970 Census population. These were

- (1) cities 25,000 and over
- (2) cities 10,000 to 24,999
- (3) towns 2,500 to 9,999
- (4) towns 1,000 to 2,500
- (5) towns less than 1,000
- (6) areas outside incorporated towns and cities.

Table 1 shows the distribution of the population in each stratum by county.

About 300 completed interviews were desired, to be divided equally between the two strata. On the basis of the 1970 Census data, a sampling rate was determined for each stratum which could

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<sup>1</sup>This Appendix was prepared by Harold Baker, Statistical Laboratory, Iowa State University, Ames, Iowa. August, 1973.

Table C-1. Distribution of universe (occupied housing units)

County	Substrata					Remainder	Total
	Cities 25,000 and over	Cities 10,000 to 24,999	Towns 2,500 to 9,999	Towns 1,000 to 2,499	Towns less than 1,000		
Inner stratum							
Boone		4,386		793	52	1,230	6,461
Hamilton				406	654	948	2,008
Hardin					544	572	1,116
Story	10,716		1,703	1,126	2,074	2,643	18,262
Total for inner stratum	10,716	4,386	1,703	2,325	3,324	5,393	27,847
Outer stratum							
Boone				633	286	1,259	2,178
Dallas			2,479	2,040	1,410	2,674	8,603
Hamilton			2,922		322	908	4,162
Hardin			3,218	690	883	1,572	6,363
Jasper		5,401		1,729	1,105	3,374	11,609
Marshall	8,765			439	1,273	2,809	13,286
Polk	68,506	8,901	6,248	810	1,014	7,980	93,459
Webster	10,112			425	1,514	3,220	15,271
Total for outer stratum	87,383	14,302	14,867	6,766	7,817	23,796	154,931

be expected to yield the desired number of interviews after allowing for some non-response and changes that may have occurred since the census. These rates were 1 out of 157.3 for the inner stratum and 1 out of 875.3 for the outer stratum.

Table 2 shows, for the substrata consisting of incorporated communities, the total number of communities in the universe and the number selected in the sample. When all the communities in a substratum were included in the sample, the overall stratum sampling rate was applied directly to the sampling materials for each community. Otherwise, a sample of communities was selected with probabilities proportional to size in terms of Census housing units. The sampling rate within a selected community was then determined such that the product of this rate and the probability of having selected the community was equal to the overall stratum sampling rate.

Within each sample community, area segments were selected at the appropriate rate. Various materials such as Census block statistics, city directories, and aerial photographs were used to define and delineate these area segments. In the open country, an area sampling frame specifically constructed for this type of sampling was used. Segments were delineated on county highway maps.

For households containing both a male head and his wife, it was desired that the male be interviewed in about half the cases and the female in the other half. This was accomplished

Table C-2. Number of communities in universe and sample

County	Cities 25,000 and over		Cities 10,000 to 24,999		Towns 2,500 to 9,999		Towns 1,000 to 2,499		Towns less than 1,000	
	U <sup>a</sup>	S <sup>b</sup>	U	S	U	S	U	S	U	S
Inner stratum										
Boone	-	-	1	1	-	-	1	1	1	-
Hamilton	-	-	-	-	-	-	1	-	4	1
Hardin	-	-	-	-	-	-	-	-	2	-
Story	1	1	-	-	1	1	2	1	10	2
Total for inner stratum	1	1	1	1	1	1	4	2	17	3
Outer stratum										
Boone	-	-	-	-	-	-	1	-	5	-
Dallas	-	-	-	-	1	-	4	1	9	1
Hamilton	-	-	-	-	1	1	-	-	3	-
Hardin	-	-	-	-	2	-	1	1	7	1
Jasper	-	-	1	-	-	-	3	-	8	1
Marshall	1	1	-	-	-	-	1	-	10	-
Polk	1	1	2	1	4	2	2	1	7	-
Webster	1	1	-	-	-	-	1	-	11	-
Total for outer stratum	3	3	3	1	8	3	13	3	60	3

<sup>a</sup>U = universe.<sup>b</sup>S = sample.

by designating (in a random manner) half the segments as "male" segments, in which the male would be interviewed, and the other half as "female" segments, in which the female would be interviewed. If a household had only a head (who, in that case, could be either male or female), that person was to be interviewed regardless of the segment designation.

### Results

Altogether, 179 occupied households were identified in the sample in the inner stratum; 146 interviews were completed for a response rate of 81.6 percent. In the outer stratum, 189 occupied households were identified from which 148 interviews were completed for a response rate of 78.3 percent.

### Estimation

For purposes of estimating totals, means, and proportions, the basic raising factor (the reciprocal of the sampling fraction) was adjusted to compensate for non-response. Since the response rate differed for males and females separate adjustments were made for each sex. The adjusted raising factors were:

Inner stratum, male	211.7
Inner stratum, female	169.4
Outer stratum, male	1069.8
Outer stratum, female	968.4

Let

$y_{ijk}$  = value of a characteristic,  $y$ , for the  $k^{\text{th}}$  person,  
 $j^{\text{th}}$  sex, in the  $i^{\text{th}}$  stratum

$w_{ij}$  = raising factor for  $j^{\text{th}}$  sex in the  $i^{\text{th}}$  stratum

$i = 1, 2$

$j = 1, 2$

$k = 1, 2, \dots, n_{ij}$  .

Then, to estimate a population total for the  $i^{\text{th}}$  stratum

$$Y_i = \sum_{j=1}^2 w_{ij} \sum_{k=1}^{n_{ij}} y_{ijk} .$$

A population mean can be estimated by

$$\bar{Y}_i = \sum_{j=1}^2 w_{ij} \sum_{k=1}^{n_{ij}} y_{ijk} / \sum_{j=1}^2 n_{ij} w_{ij} .$$

If overall totals and means are desired for the combined strata,  
 these can be obtained by

$$Y = \sum_{i=1}^2 \sum_{j=1}^2 w_{ij} \sum_{k=1}^{n_{ij}} y_{ijk}$$

and

$$\bar{Y} = \sum_{i=1}^2 \sum_{j=1}^2 w_{ij} \sum_{k=1}^{n_{ij}} y_{ijk} / \sum_{i=1}^2 \sum_{j=1}^2 n_{ij} w_{ij} .$$

These estimating procedures assume that those who were selected in the sample but were not interviewed did not differ as a group from those who were interviewed.

APPENDIX D: HOUSEHOLD CHARACTERISTICS  
OF SAMPLE POPULATION



Table D-1. Present address of respondents

Locality	Absolute frequency	Percent of total
Ames	47	16
Boone	27	9.2
Nevada	12	4.1
Madrid, Story City	7	2.4
Cambridge, Ellsworth, Roland	23	7.8
Inner Rural	30	10.2
Des Moines	70	23.8
Urbandale	13	4.4
Marshalltown, Fort Dodge	28	9.5
Webster City, Clive, Ankeny	6	2.0
Ackley, Adel, Pleasant Hill	5	1.7
Granger, Kellogg, Whitter	7	2.4
Outer Rural	19	6.5
Total	294	100

Table D-2. Age of head

Age category in years	Absolute frequency	Percent of total
19-24	30	10.2
25-30	41	13.9
31-40	59	20.1
41-50	45	15.3
51-65	59	20.1
66-80	46	15.6
81-93 (maximum)	14	4.8
Total	294	100
Mean	= 47.2	
Standard deviation	= 18.7	
Median	= 44.7	

Table D-3. Education of head

Years of schooling	Absolute frequency	Percent of total
3-5	2	0.7
7-8	44	14.9
9-11	45	15.5
12	103	35.0
13-16	61	20.7
17-18	20	6.8
19-22 (maximum)	19	6.5
Total	294	100
Mean	= 12.5	
Standard deviation	= 3.41	
Median	= 12.04	

Table D-4. Years head has lived at present address

Number of years	Absolute frequency	Percent of total
0-2	91	31.0
3-5	46	15.6
6-10	48	16.3
11-20	46	15.6
21-30	32	10.9
31-40	18	6.1
41-69 (maximum)	13	4.4
Total	294	100
Mean	= 12.03	
Standard deviation	= 13.97	
Median	= 6.27	

Table D-5. Years head has been a resident of Iowa

Number of years	Absolute frequency	Percent of total
0-2	16	5.4
3-5	5	1.7
6-10	10	3.4
11-20	17	5.8
21-30	59	20.1
31-40	47	16.0
40-60	79	26.9
60-80	52	17.6
81-93 (maximum)	9	3.1
Total	294	100
Mean = 40.91		
Standard deviation = 22.09		
Median = 39.25		

Table D-6. Number of members in household

---

Number of members	Absolute frequency	Percent of total
<hr/>		
1	51	17.3
2	99	33.7
3	43	14.6
4	45	15.3
5	28	9.5
6	17	5.8
7	10	3.4
9	1	.3
Total	294	100
Mean = 2.99		

---

Table 7. Occupation of head

---

Nature of occupation	Absolute frequency	Percent of total
<hr/>		
Professional (includes students)	59	20.1
Farmer, farm manager	33	11.2
Manager, official, proprietor	34	11.6
Clerical	26	8.8
Sales	17	5.8
Craftsman	46	15.6
Operative	28	9.5
Service worker (inc. housewife)	33	11.2
Laborer (inc. farm laborer)	14	4.8
No response	4	1.4
Total	294	100

---

Table D-8. Present status of occupation

---

Present status	Absolute frequency	Percent of total
<hr/>		
Working	208	70.7
Unemployed	1	0.3
Retired	48	16.3
Housewife	15	5.1
Student	13	4.4
Teacher at college level	7	2.4
Disabled	2	0.7
Total	294	100

---



Table D-9. Household income

Gross household income (dollars per year)	Class mean (assumed)	Absolute frequency		Percent of total	
		Original data	Adjusted for no response	Original data	Adjusted for no response
less than 3,000	2,000	33	34	11.2	11.6
3,000 to 5,999	4,500	43	47	14.6	16.0
6,000 to 9,999	8,000	54	61	18.4	20.7
10,000 to 14,999	12,500	79	84	26.9	28.6
15,000 to 24,999	20,000	60	60	20.4	20.4
25,000 and over	35,000	8	8	2.7	2.7
Refused and no response		17	0	5.8	0
Total		294	294	100	100

Table D-10. Distance to Soper's Mill

---

Distance in miles	Absolute frequency	Percent of total
<hr/>		
5-6	9	3.1
8-12	86	25.8
14-18	26	8.9
20	29	9.9
25-30	6	2.1
35	37	12.6
40	65	22.1
45-50	20	6.8
60	26	8.8
Total	294	100

---

Table D-11. Residential category in which respondent has spent half or more of life

---

Residential category	Absolute frequency	Percent of total
<hr/>		
Farm	81	27.6
Rural non-farm	18	6.1
City (greater than 10,000)	52	17.7
City (less than 10,000)	133	45.2
None of the above	10	3.4
Total	294	100

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APPENDIX E. IMPACTS OF ENVIRONMENTAL LEGISLATION  
UPON THE FEDERAL GOVERNMENT

It is the purpose of this appendix to describe more fully impacts upon the Federal government of environmental legislation, especially the 1969 National Environmental Protection Act (NEPA). Included in this appendix is a brief discussion of the Federal Water Pollution Control Act of 1972, administered by the Environmental Protection Agency. This recent act is likely to make a significant contribution to improving the quality of the nation's waters.

According to the Council on Environmental Quality in their third annual report to the Congress, NEPA has had five clearly distinguishable effects on the Federal Government, illustrating recognition of the social goal of environmental quality.

First, NEPA brings "national policies in line with modern concerns for the quality of life" (23, p. 256). Maintaining environmental quality is acknowledged to be the continuing responsibility of the Federal Government. As stated in Section 101(b) of the Act (21, p. 244):

. . . it is the continuing responsibility of the Federal Government to use all practicable means, consistent with other essential considerations of national policy, to improve and coordinate Federal plans, functions, programs, and resources to the end that the Nation may--

- (1) fulfill the responsibilities of each generation as trustee of the environment for succeeding generations;
- (2) assure for all Americans safe, healthful, productive, and esthetically and culturally pleasing surroundings;
- (3) attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable and unintended consequences;
- (4) preserve important historic, cultural, and natural aspects of our national heritage, and maintain, wherever possible, an environment which supports diversity, and

variety of individual choice;

(5) achieve a balance between population and resource use which will permit high standards of living and a wide sharing of life's amenities; and

(6) enhance the quality of renewable resources and approach the maximum attainable recycling of depletable resources.

Each Federal agency has now had its horizons broadened to include not only its own parochial concerns but also to assure all citizens each of the above quoted responsibilities.

Second, Section 102 of NEPA requires that all agencies utilize a systematic interdisciplinary approach for planning, in addition to giving unquantified environmental amenities and values appropriate consideration in decisionmaking. Most important, however, Section 102(2)(C) requires that all agencies of the Federal Government shall (21, p. 245):

(C) include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on--

- (i) the environmental impact of the proposed action,
- (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented,
- (iii) alternatives to the proposed action,
- (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and
- (v) any irreversible and irretrievable commitments of resources which would be involved in the proposed action should it be implemented.

Section 102 therefore provides a systematic way to deal with complex problems that cut across the responsibilities of several agencies. Interagency consultation is now forced and attention must be given to a broad range of effects and alternatives. The

effect of section 102(2)(C) in establishment of specific procedures for requiring environmental impact statements has been widespread, and is fully reviewed in each of the annual reports of the Council on Environmental Quality (21, 22, 23).

Third, Section 102 "has opened a broad range of Federal Government activities to public scrutiny and participation" (23, p. 256). Agencies are now required to explain their decisions where significant environmental values are concerned. A written study including alternatives must be made available, including the public, before any agency action can take place, thus ensuring public participation and contribution to more careful decisionmaking.

Fourth, agencies who traditionally have reflected narrow concerns are now required to supplement their staffs with persons of different backgrounds bringing new skills and viewpoints into agencies. This influx and interdisciplinary approach should lead to "sharper questioning of traditional assumptions within agencies" (23, p. 256).

Fifth, and of equal importance, citizen suit to vindicate NEPA is enforceable in Federal court. Requirements of NEPA, especially the "102 process" (preparation of environmental impact statements), is difficult and uncomfortable for agencies. By citizen suit and threat of suit agencies are forced to take their new tasks and responsibilities seriously. The vigilance of the courts in enforcing the Act has aided in maintaining meaning and power to the legislation. Citizen suit is also important in

determining the "significance" of environmental impact.

Hence, the 1969 National Environmental Protection Act has appeared to create considerable impact on Federal decisionmaking. The goal of environmental quality has been recognized and elevated to higher levels of priority.

This appendix refers now to the Environmental Protection Agency which is responsible for administering the recent Federal Water Pollution Control Acts of 1972 (86). This Act provides a good example of the importance of the Environmental Protection Agency in meeting social environmental quality objectives. In section 101(a) it is declared that the objective of the Act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters." The Act declared that it is a national goal to eliminate discharge of pollutants into navigable water by 1985, to attain interim goals of water quality to protect water life, to prohibit discharge of toxic pollutants in toxic amounts, and to provide Federal financial assistance to construct waste treatment works. Other stated goals are related to cooperation, education, and research and development with reference to water quality improvement.

The Federal Water Pollution Control Acts of 1972 authorized appropriations of 5 billion dollars for the fiscal year ending June 30, 1973, and 6 billion dollars for the fiscal year ending June 30, 1974, for the purpose of aiding construction of waste treatment works. Because mainly of these large expenditures and



large appropriations for other water activities, the President vetoed the legislation but his veto was overridden by both houses in Congress in October, 1972, evidencing the environmental mood of modern legislative government.